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Welcome to the XX Finnish-Austrian Orthopaedic Trauma Course

The Finnish-Austrian Orthopaedic Course is part of the professional education of the Finnish Orthopaedic Association (FOA), which has been continuously very active since FOA's inception in 1951. The first Finnish-Austrian Course was organized in Schruns in 1981 and has since been in the educational calendar of FOA biennually. This time the course will take place in hotel Forsthofgut congress centre in Leogang, Salzburgerland. This course is shorter than earlier ones, lasting three days, which makes it easier to fit it in the clinical schedule.

The physical examination, communication with the patients, and surgical skills are all essential in the work of an orthopaedic surgeon. To perfect these skills, it is important to follow literature, which presents the cutting-edge knowledge. In addition, networking with colleagues is very important to foster new ideas and to enable easy consultations when needed.

Orthopaedics has branched off to many subspecialities. Most of the courses and conferences are either focused on one narrow topic, or they are general orthopaedic meetings, where you usually meet colleagues from your own clinic or your own country. The present kind of small course is excellent for international networking.

Lecturers from Austria, Germany, Switzerland, Italy, Sweden, and Finland will elucidate different aspects of orthopaedics and trauma treatment. In addition to attending to the high-quality and multifaceted scientific program, it is again possible to participate in the social program of the course. The downhill triathlon, nick-named "bone-head competition" consists of slalom, maximum skiing speed, and bob sled competition, will be major event of the social program again. In the previous meeting in 2017, winner of this honoured challenge cup was Mikko Savolainen from Kajaani. At the moment, it seems that he is not going to defend his victory: a new "bone head" will be chosen.

I hope that all participants will enjoy this educational event and its recreational opportunities. Juha Kalske "retired" the course organizing committee two years ago after over two decades of unselfish work, for which he deserves our hearfelt thanks. Markus Parkkinen and Thomas Ibounig are new members in committee. They together with Jan Lindahl and Wolgang Grechenig have made it possible to continue this course tradition of almost 40 years. On behalf of the organizing committee, I would like to thank the whole faculty for their efforts. We all also want to thank our sponsors: without them gathering this kind of international faculty would not have been possible. Last, but not least, our greatest thanks to staff and hosts at the traditional Hotel Forsthofgut for arranging this course in their high-quality and beautiful hotel and congress center.

We look forward to continuing this long-standing tradition with you in Leogang in March!

Helsinki, February 5, 2019.

Mikko Manninen

Chair of the Organizing Committee
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XX Finnish-Austrian Orthopaedic Trauma Course
10.-13.3.2019

Hotel Forsthofgut Congress Centre
Leogang-Saalbach, Austria

Finnish Orthopaedic Association

Established 1951

XX Finnish-Austrian Orthopaedic Trauma Course

Hotel Forsthofgut Congress Centre, Leogang-Saalbach, Austria

Scientific Program

Program chairs Mikko Manninen and Jan Lindahl

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Finnish Orthopaedic Association

XX Finnish-Austrian Orthopaedic Trauma Course 10.-13.3.2019

Hotel Forsthofgut Congress Centre, Leogang-Saalbach, Austria

Scientific Program

Sunday, March 10, 2019

12.00 Registration
18.00 **OPENING CEREMONY**

Monday, March 11, 2019

08.00 **SESSION I – Pelvic and lower extremity surgery**
Chairmen Jan Lindahl and Axel Gännslen

08.00-08.25 Treatment of polytraumatized patients in Germany
Axel Gännslen
08.25-08.50 Management of sacral fractures
Jan Lindahl
08.50-09.15 Novel approaches for proximal tibial fractures
Markus Parkkinen
09.15-09.40 Hip arthrodesis
Axel Gänsslen

09.40-10.00 Coffee and technical exhibition

10.00 **SESSION II – Upper Extremity**
Chairmen Thomas Ibounig and Wolfgang Grechenig

10.00-10.25 MIPO of the humerus
Wolfgang Grechenig
10.25-10.45 Physical examination and diagnostics of shoulder pain
Thomas Ibounig
10.45-11.10 Shoulder imaging
Frank Bensch
11.10-11.30 Natural history (course of progression) of rotator cuff tears
Karl Wieser
11.30-11.50 The value of shoulder joint aspirations
Karl Wieser
11.50-12.00 Discussion

12.00 Lunch and technical exhibition

16.00-18.00 **Discussions in groups**

Virtual reality
1) VR in orthopaedic trainining
   Arne Schlenzka
2) Modern technologies in shoulder surgery
   Karl Wieser

Back to reality – Remote damage control surgery
Antti Oksanen

Tuesday, March 12, 2019

08.00 **SESSION III – Special issues in lower leg orthopaedic surgery**
Chairmen Davide Donati and Mikko Rantasalo

08.00-08.30 Pelvis replacement
Davide Donati
08.30-09.00 Total Femur
Davide Donati
09.00-09.20 Deformed knee and osteoarthrosis - how to treat?
Mikko Manninen
09.20-09.40 Haemophilic Arthropathy
Heidi Danielson

09.40-10.00 Coffee and technical exhibition

10.00 **SESSION IV – Sports / Mixed**
Chairmen Markus Parkkinen and Heidi Danielson

10.00-10.25 Complications in metal removal
Wolfgang Grechenig
10.25-10.50 Concussion in sports
Jari Siironen
10.50-11.15 Vertebral fractures - is there a valid concept for treatment recommendation today?
Cyrill Suter, Basel University
11.15-11.35 Medial high tibial opening wedge osteotomy for knee osteoarthritis;
ten year results in Helsinki University Hospital
Jani Puhakka
11.35-11.55 Enthesopathies of the knee region
Thomas Schlenzka
11.55-12-00 Discussion

12.00 Course photography
12.15 Lunch and technical exhibition

16.00-18.00 **Discussion in groups**

Periprothetic fractures
Olli Komulainen
Patient injuries – malpractise
Eero Hirvensalo

Wednesday, March 13, 2019

08.00 **SESSION V Foot surgery**
Chairmen Oliver Michelsson and Mikko Hautamäki

08.00-08.25 TC arthrodesis with plate fixation
Mikko Hautamäki
08.25-08.50 Infections and skin necrosis in Achilles region
Vesa Juutilainen
08.50-09.15 Current treatment of Achilles tendon rupture
Mikko Miettinen
09.15-09.40 Hallux valgus – treatment algorithm
Oliver Michelsson

09.40-10.00 Coffee and technical exhibition

10.00 **SESSION VI Hip and Knee**
Chairmen Mikko Manninen and Jörg Schilcher

10.00-10.30 Aseptic loosening in prosthetic joint replacement
Jörg Schilcher
10.30-10.55 Tourniquet or not in Total Knee Arthroplasty?
Mikko Rantasalo
10.55-11.20 Atypical femur fractures
Jörg Schilcher
11.20-11.45 Avascular necrosis of the femoral head; current diagnostics and treatment
Tomi Simons
11.45-12.00 Discussion

12.00 **END OF COURSE**

Finnish-Austrian Orthopaedic Trauma Meetings: Schruns 1981, Bad Hofgastein 1983, Oberlech 1985, Ischgl 1987, Oberlech 1989, Obergurgl 1991, Obergurgl 1993, Oberlech 1995, Ischgl 1997, Ischgl 1999, Oberlech 2001, Oberlech 2003, Obertauern 2005, Serfaus 2007, Oberlech 2009, Zauchensee 2011, Oberlech 2013, Oberlech 2015, Oberlech 2017, Leogang 2019

Treatment of Polytraumatized Patients in Germany

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Introduction

Already Lorenz Böhler from Vienna, Austria stated in 1929, that the trauma surgeon is responsible for the entire chain of care, from rescue to rehabilitation, including the treatment of fractures but also soft tissue injuries, such as vascular, abdominal, or pelvic organ injuries [1,2].

This led to the initiation of specific resident and other educational programs for trauma physicians and resulted in an independent subspecialty for accident and trauma surgery (Unfallchirurgie) in the early 70ies [1].

The primary management aim today is clearly defined, that every severely injured person should have the same chance of survival anywhere in Germany at any time [3].

According to the German Whitebook of Polytrauma treatment, this goal is achieved by standardization of structures, processes, outcome and patient safety analyses, contractual agreements between hospitals, advanced training and strategies to improve outcome quality, defined criteria for expertise and capacity and defined referral criteria.

For optimal care of the patient, the prehospital and inhospital treatment-free interval should be as short as possible and a high level of expertise is recommended. The latter includes, that polytraumatized patients should be treated only in hospitals with a 24-hour availability of comprehensive emergency diagnostics (e.g. CT, interventional radiology), a 24-hour availability of emergency treatment modalities (interdisciplinary emergency and OR management, special OR teams), adequate (excellent) intensive care, immediate access to complementary surgical specialists (e.g. neurosurgery, visceral surgery, vascular and cardiac surgeons) and early commencement of holistic rehabilitative therapies.

Therefore, German hospitals work together in local and regional networks (TraumaNetzwerk DGU®). This network strategy needs educational efforts for all in the polytrauma management involved persons, which is now based on special, standardized courses to implement specific knowledge of care for the severely injured and to prevent treatment errors. These courses include prehospital management courses (PHTLS®), emergency room management courses (ATLS®, ETC®), emergency surgical treatment courses (DSTC™) and team training courses (Hand over Team Training [HOTT®]).

Prehospital Care

Prehospital care focusses on the concept "Treat first-what-kills-first" and therefore a standardized "Primary Survey" according to the PHTLS or ATLS concept is proposed with a rapid and structured assessment of the patient at the scene to detect and control of (potentially) life-threatening conditions, which focusses on ABC stabilization of the patent.

The rescue frameworks include physician-staffed helicopter and ALS units and paramedic-staffed ambulance vehicle systems. A concurrent alarm is possible and the resulting costs are completely covered by German insurance companies, even in unnecessary alarms or transport [1].

Recent data indicate, that in Germany nearly all severely injured patients (>95%) are seen by an emergency physician at the scene, who is transferred by car or rescue helicopter.

Despite this high level of medical care, the prehospital time did not change during the last years and is still approximately 70 minutes with a scene time of 30 minutes [4].

Advanced prehospital treatment by physicians

resulted in high intubation rates in patients with severe traumatic brain injury and decreased intubation rates in conscious patients. During the last decade, overall, a reduced volume replacement was observed, which is based onthe recent understanding and the pathophysiological knowledge of volume replacement [4].

At the end of prehospital evaluation, the emergency physician has to decide to which hospital the patient should be transferred. Based on the introduction of the TraumNetworkD DGU of the German Trauma Society, three levels of care are available, depending on yearly the frequency of treating polytraumatized patients [5]:

- level I: high experience
- level II: moderate experience
- level III: low experience

Clear criteria are available for each level of care hospital, which are primarily based on available medical specialities [6].

This specialization is relevant, as treatment data clearly indicate, that level I hospitals were associated with a survival benefit of 1% for this patient group compared with low-volume hospitals and the yearly volume of treated patients was identified as an independent positive predictor of survival [7].

With the decision of the emergency physician to activate a specific hospital, inhospital trauma team activation is performed on standard parameters:

- physiological parameters
- special injury pattern
- specific injury mechanisms

Emergency Room (ER) Care

ER care is performed according to established focused algorithms, which are based on the Advanced Trauma Life Support (ATLS) concept. The basis of this concept is to avoid, detect and treat life threatening injuries without definite knowledge of the exact diagnosis and medical history.

This priority-based concept is relevant, as data indicate, that in the ER area, most management errors occur affecting the outcome [8].

With the introduction of the Trauma-Registry® DGU, recently data are available to analyze the effect of mangament.

The Trauma-Registry® DGU is a database on treatment of >33.000 trauma cases including data from > 600 hospitals [4]. It covers approximately 90% of all severely injured patients treated in Germany and about 100 different data items are recorded every year for each patient and therefor this registry is the basis for a detailed quality management.

Analyzing these data resulted in several lessons learned during the last decade. In summary some special results are presented [4, 9]:

- shorter time from admission to resulting emergency diagnostics, e.g. FAST examination (25min – 7min), chest x-ray (17min – 12min) and pelvic a.p. x-ray (25min – 15min)
- earlier initiation of emergency surgery (45min – 39min)
- earlier arrival on the ICU (121min – 113min)
- reduced blood transfusion (approx. 15%) and massive transfusion rates (<5%) according to the "new" pathophysiological knowledge
- increasing use of CT-diagnostics (whole body CT (WBCT), any CT)

Additionally, several important results were obtained from data analyses of the Trauma-Registry® DGU data:

- conventional x-ray/FAST/CT examination was compared to WBCT and showed no differences regarding patient outcomes [10]
- data analysis resulted in a base deficit (BD) renaissance, as it could be observed, that a worse BD was associated with a mortality increase from 7.4% to 51.5% depending on injury severity [11]
- the importance of coagulopathy was high-lighted; coagulopathy was present depending on the injury severity and the amount of volume replacement, leading to a more modern volume management [12]
- an overall improved outcome with reduced mortality rates could be observed in the last decade [4]

The historical and still valuable definition of polytrauma by Harald Tscherne was recently modified, based on these new informations from the Trauma-Registry® DGU.

Pape et al. included physiological and injury-related parameters as age, severity of traumatic brain injury and the presence of hypotension, acidosis and coagulopathy in a new definition and could show a dependency of mortality in relation to the frequency of these additional parameters [13].

Overall, treatment of polytraumatized patients was significantly affected during the last decade by data analyses from the Trauma-Registry® DGU.

Further Trauma-Registry® DGU –Effects

Beside effects on ER treatment, further effects could be analyzed based on available data.

In several hospitals structural changes occurred depending on these analyses with introduction of point-of-care diagnostics in the ER and ICU phase, change from conventional x-ray diagnostics to digital x-rays and today, standardized use of multislice CT; increased personal training of all persons dealing with polytrauma mangament, including ER nursing staff (ATLS® and PHTLS®), introduction of time efficient treatment algorithms in several hospitals, identification of optimized indicators for good treatment quality and a reduction of the average total trauma treatment time for patients with an ISS ≥16 from initially 90 to 37 minutes [14].

TraumNetzwerkD DGU

Initiation of local Trauma Networks lead to several local treatment advantages. Based Whitebook 2012, which was established in 2006, evidenced-based treatment and management guidelines were proposed and regional trauma networks were established based on a standardized audit process. The primary aims and established results of these networks include [15, 16]:

- defined admission criteria
- standardized structural organizational requirements (e.g. standardized ER equipment)
- standardized personnel requirements including professional medial qualification (= 50% ATLS®-Providers)
- "local" quality optimization
- increasing treatment efficiency
- definition of clear parameters for regional interhospital transfers
- initiation of internal and external quality programms
- initiation of local cooperations
- continuing education between network partners
- initiation of interhospital telecommunication systems
- initiation of error management, treatment quality management/feedback

Presently, >90% of the German area is covered by 53 local/regional networks consisting of at least one level I hospital and further level II and II hospitals [15].

ICU Treatment and Rehabilitation

After ER treatment and emergency treatment, patients are transferred to standardized ICU wards.

Here, on-going ABC stabilization, kinetic treatment of relevant chest injuries, extended diagnostics & monitoring (ICP, compartment etc.), early enteral feeding and early initiation of physiotherapy is performed and criteria for secondary treatment procedures are defined.

Rehabilitation already starts during hospital stay, as evidence exists about benefits of early „continuous chain rehabilitation", which is continued in the post-acute phase [17].

The relevance of rehabilitation is well known, as persistent disabilities late after trauma are frequent. 73% of patients report on significant pain, only 67% are mentally normal, only half of these patients is socially reintegrated and 41% report on some kind of depression [18].

Summary

The present German concept of polytrauma management is based on historical experience, but a clear "new" concept is now proposed by experience from improved quality of care from established Trauma-

Networks, which compensate local lack of treatment experience.

Optimal treatment starts already at the scene and is further standardized during the ER phase, the emergency surgical phase and the ICU and Rehabilitation phase.

References

1. Sturm, J., H. Pape, and T. Dienstknecht, Trauma care in Germany: an inclusive system. Clin Orthop Relat Res, 2013. 471: p. 2912-2923.

2. Maegele, M., Prehospital care for multiple trauma patients in Germany. Chin J Traumatol, 2015. 18: p. 125-134.

3. Surgery, G.S.f.T., Whitebook. Medical Care of the Severely Injured. 2nd revised and updated edition. Georg Thieme Verlag KG, Stuttgart, 2012.

4. DGU(®), T., 20 years TraumaRegister DGU(®): development, aims and structure. Injury, 2014. 45: p. S6-S13g.

5. Debus, F., et al., Numbers of Severely Injured Patients in Germany. A Retrospective Analysis From the DGU (German Society for Trauma Surgery) Trauma Registry. Dtsch Arztebl Int, 2015. 112: p. 823-829.

6. Frink, M., et al., Multiple Trauma and Emergency Room Management. Dtsch Arztebl Int, 2017. 114: p. 497-503.

7. Zacher, M., et al., Association between volume of severely injured patients and mortality in German trauma hospitals. Br J Surg, 2015. 102: p. 1213-1219.

8. Bouillon, B., Klinische Erstversorgung, Schockraummanagement. Orthopädie und Unfallchirurgie up2date, 2006. 1: p. 77-89.

9. Ruchholtz, S., et al., Reduction in mortality of severely injured patients in Germany. Dtsch Arztebl Int, 2008. 105: p. 225-231.

10. Topp, T., et al., Radiologic diagnostic procedures in severely injured patients - is only whole-body multislice computed tomography the answer? Int J Emerg Med, 2015. 8:3. doi: 10.1186/s12245-015-0053-8. eCollection 2015.

11. Mutschler, M., et al., Renaissance of base deficit for the initial assessment of trauma patients: a base deficit-based classification for hypovolemic shock developed on data from 16,305 patients derived from the TraumaRegister DGU®. Crit Care, 2013. 17(2):R42. doi: 10.1186/cc12555.

12. Maegele, M., Acute traumatic coagulopathy: Incidence, risk stratification and therapeutic options. World J Emerg Med, 2010. 1: p. 12-21.

13. Pape, H., et al., The definition of polytrauma revisited: An international consensus process and proposal of the new 'Berlin definition'. J Trauma Acute Care Surg, 2014. 77: p. 780-786.

14. Helm, M., et al., [The TraumaRegister DGU® as the basis of medical quality management. Ten years experience of a national trauma centre exemplified by emergency room treatment]. Unfallchirurg, 2013. 116: p. 624-632.

15. Ruchholtz, S., et al., TraumaNetzwerk DGU(®): optimizing patient flow and management. Injury, 2014. 45: p. S89-S92.

16. Ernstberger, A., M. Koller, and M. Nerlich, [Quality circle in a trauma network of the German Association for Trauma Surgery. Upgrading patient care]. Unfallchirurg, 2011. 114: p. 172-181.

17. Andelic, N., et al., Does an early onset and continuous chain of rehabilitation improve the long-term functional outcome of patients with severe traumatic brain injury? J Neurotrauma, 2012. 29: p. 66-74.

18. Simmel, S. and V. Bühren, [Sequelae of severe injuries : consequences for trauma rehabilitation]. >Chirurg, 2013. 84: p. 764-770.

Management of sacral fractures

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Pelvic ring disruptions are relatively rare injuries and account for approximately 1% of fractures that require hospitalization among people ≥ 16 years in Finland (1). High-energy unstable pelvic ring disruptions are frequently associated with multiple concomitant injuries. Among patients with multiple-traumas, up to 25% have pelvic ring injuries (2-4), which also are a significant source of mortality and morbidity (5-8).

During the past few decades, the rate of osteoporotic pelvic fractures in the older population has increased consistently (9,10). Low-energy fractures in osteoporotic patients are defined as fragility fractures of the pelvis (FFP). The term "fragility fracture" is used instead of stress, fatigue or insufficiency fracture to describe osteoporosis-associated fractures due to a minor trauma or with no obvious trauma history (11,12). Fragility fractures of the sacrum (FFS) are often combined with a fracture of the anterior pelvic ring; hence they are classified as a part of fragility fractures of the pelvis (FFP). Because of low-energy trauma mechanism, multiple injuries are rare in these patients. Survival rate of FFP can be compared to survival rate of hip fractures. One year mortality is 27% (13).

Fracture patterns in the sacrum range from crush lesions in the lateral sacrum to spinopelvic dissociations. Various options for management for different type of sacral fractures have been proposed.

Classification

Pelvic ring injuries

According to AO/OTA classification system the pelvic ring fractures are graded into three types, A, B, and C, in order of increasing severity (14). Type A injuries are stable fractures, which fall into two categories. The first category includes fractures that do not involve the ring, which include isolated transverse fractures of the sacrum below the SI-joint level (61-A3), avulsion fractures, and fractures of the iliac wing. The second category includes direct-blow fractures in the anterior arch; these involve pubic rami and/or symphysis pubis.

Type B injuries are rotationally unstable but vertically and posteriorly stable. They may be caused by external rotatory forces (open book injuries) or internal rotatory forces (lateral compression injuries). In type B lateral compression injury (61-B2), the hemipelvis is typically driven into an inward and upward rotation, which causes shortening and vertical displacement at the rami fracture site or disruption of the SP (overlap of the pubis). The posterior sacroiliac complex, typically the anterior part of the lateral sacrum is impacted, but there is no vertical instability, because the posterior ligaments are intact. A lateral compressive force may cause two types of injury. In one type, anterior and posterior lesions occur on the same side, and in the other type, displacements occur on opposite (contralateral) sides. The ligaments of the pelvic floor remain intact, which ensures vertical and posterior stability.

Type C injuries are completely unstable fractures, which exhibit both rotational and translational instability (61-C1). Posterior pelvic ring injuries form the basis of the subgroups; a fracture through the posterior ilium (C1.1), sacroiliac dislocation and fracture dislocation (C1.2), and sacral fractures (C1.3). The posterior injury may be bilateral. The bilateral posterior lesion may be vertically stable on one side and unstable on the other (61-C2), or unstable on both sides (61-C3).

Sacral fractures

Sacral fracture patterns are commonly categorized using the Denis classification system (15). It divides sacral fractures into three zones: alar (zone 1), foraminal (zone 2) and central (zone 3). Denis, Davis and Comfort (15) found that injury to nerves occurred in 5.9% of fractures lateral to sacral foramina. In transforaminal fractures 28.4% of patients had a neurological deficit. Central fractures had the highest prevalence (56.7%) of nerve injury.

Spinopelvic dissociation

The spinopelvic dissociation is a rare, high-energy injury pattern located in the sacrum. It is characterized by bilateral vertical sacral fractures in conjunction with a transverse sacral fracture. Denis's system does not recognize the combination of bilateral vertical and transverse fracture lines that cause spinopelvic dissociation. This injury causes the spine and upper central segment of the sacrum to dissociate from the pelvic ring and caudal sacral segments.

Roy-Camille et al. (1985) described the spinopelvic dissociation injury, but they classified only the transverse sacral fracture, not the bilateral vertical fracture components (16). Roy-Camille et al. divided transverse sacral fractures into three types. However, the Roy-Camille classification of these fractures (1985) is not prognostic of neurological impairment after operative treatment (17). The outcome study of H-shaped sacral fracture with spinopelvic dissociation by Lindahl at al. (2014) showed that neurological recovery and clinical outcome were associated with the degree of initial translational displacement of the transverse sacral fracture (17). Therefore it is useful to subcategorize transverse sacral fractures, as partially displaced or completely displaced, and add these subcategories to the original Roy-Camille type 2 and 3 sacral fractures. According to this modified classification system of transverse sacral fractures: type 1 is a flexion injury without translational displacement; type 2a is a flexion injury with partial anterior translational displacement of the caudal sacral segment; type 2b is a flexion injury with complete anterior translational displacement of the caudal sacral segment; type 3a is an extension injury with partial posterior translational displacement of the caudal sacral segment: and type 3b is an extension injury with complete posterior translational displacement of the caudal sacral segment (17).

In addition to H-shaped injuries, other possible sacral fracture patterns that occur with spinopelvic dissociations include the U-, Y-, and T-shaped sacral fractures (18-22).

Fragility fractures of the pelvis (FFP)

The Rommens and Hofmann classification system of fragility fractures of the pelvis (FFP) differentiate isolated anterior or posterior pelvic injuries as well as a combinations of these including the degree of displacement and hence the degree of pelvic instability (23). It divides FFP into four types: type I are isolated injuries of the anterior pelvic ring; type II represent non-displaced fractures of the sacrum; type III exhibit a higher degree of instability presenting a complete unilateral sacral or sacroiliac complex disruption and a complete fracture of the anterior pelvic ring with some degree of displacement; and type IV are injuries with bilateral displaced posterior lesions. A bilateral sacral fracture connected with a transverse fracture line is classified as FFP type IVb, functionally being a highly unstable spinopelvic dissociation. A combination of bilateral posterior pelvic disruption including a sacral fracture and an anterior pelvic ring injury is classified as FFP type IVc.

Radiographic examination

The anteroposterior (AP) pelvic radiograph is the principal diagnostic tool and gold standard for assessing patients with suspected pelvic injuries. An AP pelvic radiograph is mandatory for the initial assessment in the emergency evaluation, and it provides in most cases the diagnosis. CT is very sensitive for detecting pelvic fractures and identifying associated injuries that often accompany the pelvic fracture. CT scans are best for delineating the posterior anatomy, and they are extremely useful for identifying injuries of the sacroiliac complex, the sacrum, SI-joint, or iliac wing (24). Morover, CT is very valuable for assessing of pelvic stability. CT images clearly indicate whether a posterior pelvic injury is impacted and stable or disrupted and unstable (14).

Anteroposterior pelvis radiograph and CT show the vertical sacral fracture lines. However, the diagnosis of traumatic spinopelvic dissociations is often missed or delayed in AP pelvic radiograph because of the difficulty in imaging the upper sacrum and the frequency of concomitant severe injuries. Angulation of the fractured sacral segment can produce a paradoxical inlet view of the upper sacrum on the standard anteroposterior pelvic radiograph (18). Delayed diagnosis is avoided by high clinical suspicion, early lateral sacral radiographs, and pelvic CT sagittal reconstructions.

Diagnostics of fragility fractures of the pelvis is more challenging, because conventional pelvis radiographs have a lower sensitivity in detecting low-energy sacral fractures than high-energy sacral

fractures. When a fracture of the pubic rami is diagnosed, a CT-scan of the pelvis is performed to assess the full extent of the injury. FFS often show a discontinuation of the anterior sacral cortex laterally to the sacral foramina with only minor displacement. Sometimes, a small crush zone medially to the SI-joint can be detected (11). In elderly patients conventional radiographs of the lumbar spine are also carried out to exclude other pathologies in elderly suffering from low back pain. Magnetic resonance imaging (MRI) of the lumbar spine and sacrum can be used to exclude occult osteoporotic fractures of the sacrum or the lumbar spine (25).

Three-dimensional (3D) image reconstructions based on CT scans of the pelvis provide considerable information on the location and stability of pelvic fractures. 3D CT enhances the understanding of each fracture lines and the separate fragments by simulating the gross anatomy of the injured pelvis. In particular, rotational deformities and displacements of the pelvis are best visualized with 3D CT. Pelvic AP radiography and CT with 3D image reconstructions will confirm the type of pelvic injury, the presence or absence of instability, and the degree of each displacements. It is necessary to acquire 3D CT images prior to a definitive surgical treatment of an unstable pelvic fracture. 3D CT facilities are currently available in most trauma centres; therefore, oblique pelvic inlet and outlet views are no longer essential for diagnostics or for preoperative planning.

Neurologic injury

AO/OTA type C1.3 fractures of the sacrum may result in a neurologic injury in up to 40 % of cases (26) and sacral fracture-dislocations with spinopelvic dissociation in up to 100 % of cases (17,27). The nerve injury may involve more than one nerve root, and be unilateral or bilateral depending on the fracture pattern and location. The injury can range from a neuropraxic injury due to nerve contusion or shearing injury, to transection of nerve roots.

In H-shaped sacral fractures with spinopelvic dissociation, the transverse fractures are angled, and they undergo translational displacement, or even complete fracture displacement. This condition results in gross spinopelvic instability and neurological deficits in the cauda equina. Another common presentation is an injury to the L5 and S1 nerve roots associated with vertical sacral fracture lines. The L5 nerve root can be injured as a result of vertical shear displacement of the sacrum and is often accompanied by a fracture of the transverse process of L5. A S1 nerve root injury is associated with transforaminal (zone II) sacral fractures (15).

Clinical examination of trauma patients sustaining sacral fractures requires both examination of lower extremity sensory and motor function, and examination to identify injuries to the lower sacral plexus. A rectal examination is performed to evaluate sphincter contraction and to exclude possible rectal injury as a sign of an open pelvic fracture. Light touch and pinprick sensation should be assessed for the perianal dermatomes of S2 to S5.

Conservative treatment

In type B lateral compression injuries, the anterior part of the sacrum or the sacroiliac complex is typically impacted, but there is no vertical instability. These compression type fractures of the lateral sacral ala can be treated non-operatively. If the hemipelvis is internally rotated and there is a clear displacement on the rami fracture site, partial weight-bearing on the affected side is recommended for 4 to 6 weeks.

Most fragility fractures (FFP type 1 and 2 injuries) of the pelvis can be treated non-operatively (23). They are minor lesions with little instability. Treatment consists of pain medication and mobilization out of bed and weight-bearing in the limit of pain of the injured side. As soon as the pain intensity diminishes, full weight-bearing will be achieved. When intense pain persists or increases, additional CT examinations are recommended in order to exclude fractures or displacements that may not have been visible or present at admission. Pain can persist for as long as six to eight weeks after the minor trauma.

Surgical treatment

Vertically unstable sacral fractures

An external fixator applied anteriorly cannot restore enough stability to an unstable type C disruption of the pelvic ring to allow mobilization of the patient without risking redisplacement of

the fracture (14,26,28). Therefore open or closed reduction and internal fixation has become the method of choice for stabilization of type C pelvic ring injuries with sacral fractures.

Biomechanical studies have shown that the best stability in type C pelvic ring injuries can be achieved by internal fixation of the posterior and anterior pelvic ring injuries (14,29). Therefore fixation of any associated anterior pelvic ring injury is essential to improve the fixation stability of the whole pelvic ring (30,31). However, non-displaced and stable rami fractures might be treated non-operatively.

Sacral fractures are the most difficult to reduce and stabilise. Biomechanical studies have demonstrated differences in stiffness of fixation constructs in sacral fractures (32,33). Following anatomic reduction, there are several different type of fixation techniques for vertically unstable sacral fractures including iliosacral screws, transiliac bars, transiliac plates, local small plates, and spinal instruments.

Iliosacral screw fixation. Iliosacral screw fixation is the gold standard for fixation of vertically unstable sacral fractures. Severely displaced sacral fractures are typically approached posteriorly, with the patient in the prone position, through a vertical incision medial to the posterior superior iliac spine without releasing the gluteal muscles from the outer side of the iliac crest. The sacral fracture is observed and reduced with forceps. After achieving reduction, the sacral fracture is fixed with two percutaneously placed 7.0-7.3 mm fully threaded cannulated screws (through a separate small lateral skin incision) from the outer aspect of the ilium through the SI-joint into the body of S1 under fluoroscopic guidance. Minimally displaced sacral fractures are suitable for closed reduction, either in the supine or prone position, and percutaneous IS-screw fixation. The screws should be placed at least past the midline of the sacrum.

Three dimensional computer-assisted navigation facilitates screw placement with less radiation and a similar operation time, compared to the conventional fluoroscopy-guided procedure (34). A three-dimensional image intensifier can also be used intraoperatively to control the quality of reduction and to guide correct placement of the iliosacral-screws.

Ilio-iliacal techniques. There are four main options: extraosseous transiliac bars (sacral bars), intraosseous sacral bars, ilio-iliacal plates (35,36), and an ilio-iliacal internal fixator (37). Ilio-iliacal plating techniques have some disadvantages, including limited reduction possibilities, bilateral bridging of the SI-joint in the unilateral injury pattern, difficulty in precontouring the plate, and a higher rate of symptomatic implants (35,38).

Direct plate fixation. A sacral fracture fixation with small fragment implants (small sacral plates) has been introduced as an alternative approach (39,40). This direct plating technique might be useful in sacral fractures lateral to the sacral foramina (Denis zone I). However, in transforaminal sacral fractures (zone II), short local plates cannot be used without screw penetration into the sacral canal; therefore, these fractures require longer transverse plates that pass over the midline.

Combined techniques. In patients with a comminuted sacral fracture a threaded compression transiliac rod might be used to anchor the injured hemipelvis to the contralateral ilium to help supplement iliosacral screw fixation (Töölö hospital experience).

Spinopelvic dissociation

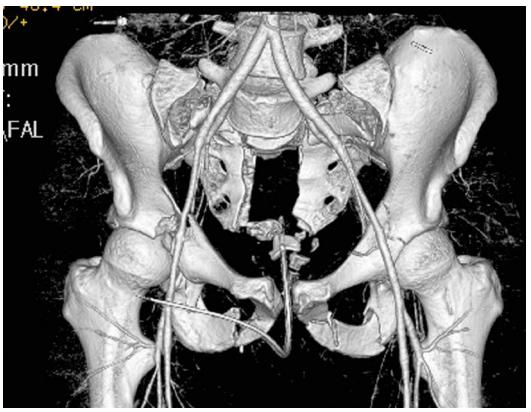
Treatment for a H-shaped sacral fracture with spinopelvic dissociation has evolved from a non-operative approach to open reduction and segmental lumbopelvic fixation (16,17,27,41). The goals of treatment are realignment, restoration of spinopelvic stability, and decompression of the neural injury indirectly with fracture reduction and/or directly with a sacral laminectomy. Fixation is achieved by connecting the lumbar spine to the ilium with segmental spinal fixation system. Allen and Ferguson (1984) were the first to report on their experience with the Galveston technique, where the distal fixation points are located on the posterior part of the iliac wings, above the sciatic notch, and between the laminas (42).

Töölö Hospital lumbopelvic fixation technique (17). A staged reconstruction is performed when a combined H-shape sacral fracture and an additional anterior pelvic ring injury is present. The injuries of

the anterior part of the pelvic ring are most commonly operated on first (Figure 1). The method for lumbopelvic fixation includes two pairs of 6-mm lumbar pedicle screws, bilateral 6-mm longitudinal rods, one or two transverse connectors, and two pairs of 8-mm iliac screws. Longitudinal rods are connected to L4 and L5 pedicle screws after having been contoured to lie close to the posterior lamina of the sacrum and medial to the PSISs. One or two transverse connecting rods between longitudinal rods are used to secure the fixation. The operative reduction and correction of displacements and rotational deformities of both hemipelves and the caudal segment of the sacrum are performed using two pairs of reduction clamps and caudal distraction of the distal part of the sacrum. The longitudinal rods fixed to pedicle screws act as a counter force for the final vertical correction of the sacral fracture components. Simultaneous reduction of the hemipelves into a dorsal direction by traction is performed by the second pair of reduction clamps. To achieve this goal, simultaneous bilateral manual femoral traction and hyperextension of both hip joints are also used. When accurate reduction is obtained, the lumbar spine and central upper sacral segment is fixed to the pelvic ring by placing two pairs of 8-mm iliac screws into the iliac bones with the Galveston technique (42) and connecting them to the longitudinal rods with special clamps.

Indirect decompression of the lumbar (vertical fracture lines) and sacral neural roots (the transverse fracture line) is achieved through reduction of all the sacral fracture components (Figure 1).

1a)



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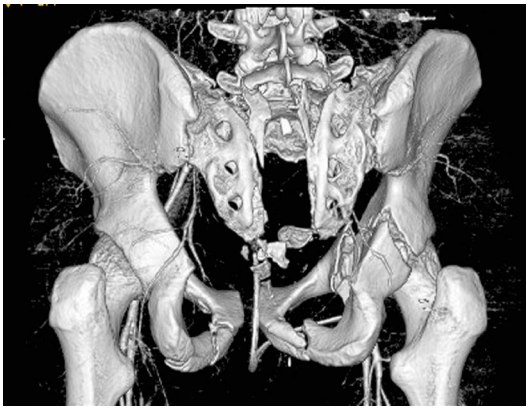

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Figure 1…

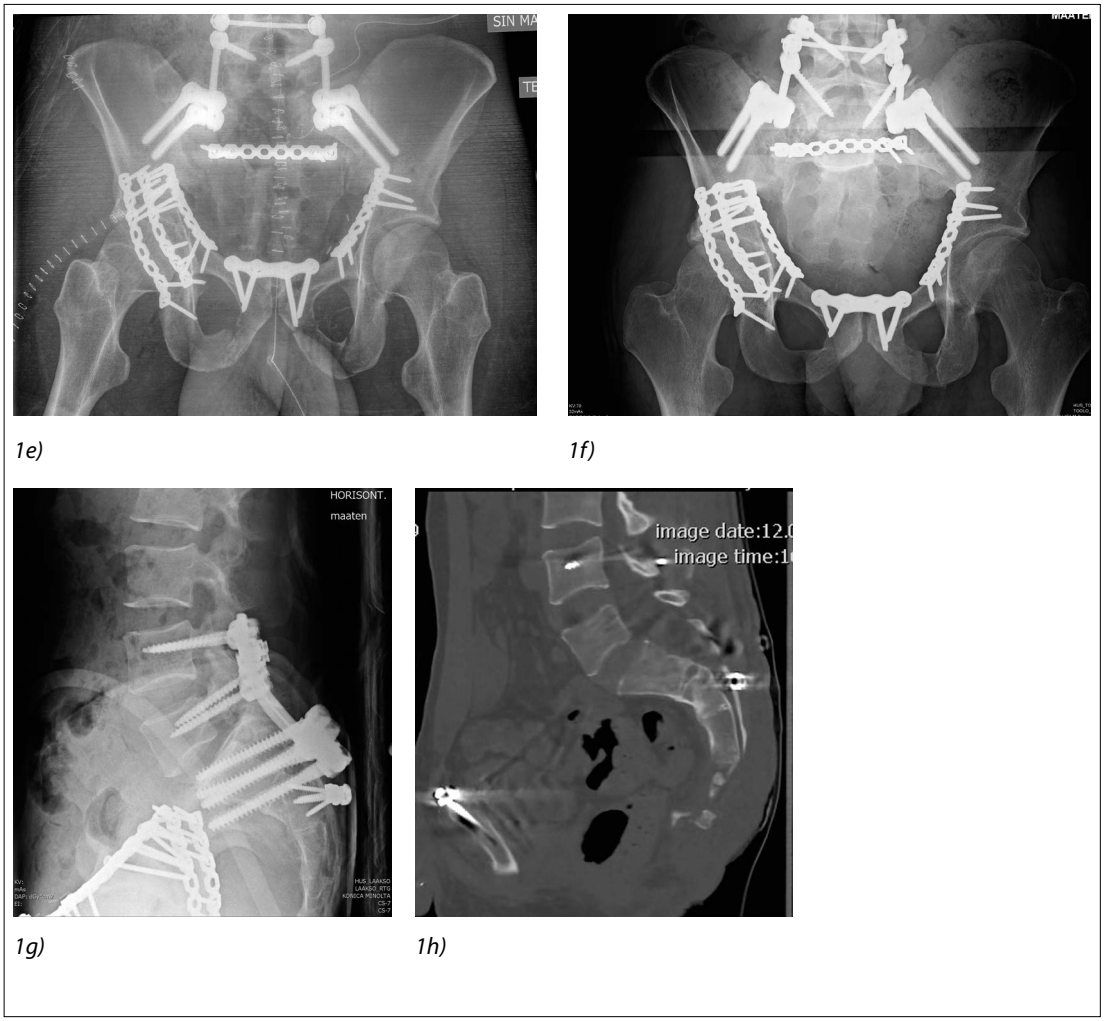


Figure 1. A staged reconstruction of a T-shaped sacral fracture-dislocation with spinopelvic instability, cauda equina injury and bilateral L5-S1 nerve roots injuries, in a 32 years-old male who jumped from the fifth floor. (a-c) Bilateral acetabular fractures, a T-type fracture on the right side, an anterior column fracture on the left side, and disruption of the symphysis pubis associated with spinopelvic dissociation are shown in pelvis x-ray (a) and 3D-reconstructed images of the anterior (b) and the posterior pelvis (c). (d) CT image shows a comminuted type 3b transverse sacral fracture with complete translational fracture displacement at the level of S2. (e-f) Pelvis x-ray images (post op and 2,5 years after the operation) and (g-h) lateral x-ray and sagittal CT image show the result of the three-stage pelvic reconstruction. The first stage consisted of anterior fixation of both acetabulum fractures and the symphysis pubis; the second stage consisted of a segmental lumbopelvic fixation and an additional transverse plate fixation of the sacrum, and the third stage consisted posterior fixation the the right acetabulum. Two and half years from the trauma, the patient was able to walk without aids, had slight pelvic pain at rest (VAS 2-3/10), and reported slight deficiencies in micturition and slight bowel dysfunction.

Direct decompression by sacral laminectomy is recommended to perform for all completely displaced transverse sacral fracture with occlusion of the central sacral canal and in the patients in which a clear translational displacement remained in the transverse fracture line after the final reduction as assessed by a true lateral sacral fluoroscopic view.

FFP

Rommens and Hofmann (2013) recommend surgical treatment in FFP (type 3 and 4), if patient is not able to mobilize out of bed during the first 3-5 days despite pain therapy or if increasing dislocation of fracture fragments during the early follow-up period is noticed (23). Displaced (unstable) FFS are treated with minimal-invasive fracture fixation, either by transsacral screws (Figure 2) or bilateral iliosacral screws (23,43). In FFP with a concomitant displaced anterior pelvic ring injury, anterior fixation is recommended (12). However, if FFP is diagnosed with delay and a strong callus formation in the anterior part of the pelvis is visible, the rami fractures can be treated non-operatively. H- or U-type fracture patterns functionally represent a spinopelvic dissociation. These injuries are unstable and should be fixed in a minimal invasive way in cases with no or only slight displacement. However, if gross displacement is present, a lumbopelvic stabilization is recommended.

Outcomes

In a systematic review of treatment modalities and outcomes of pelvic ring disruptions, Papakostidis et al. (31) concluded, that fixation of all the injured elements of the pelvic ring yield better anatomical results compared to more non-operative therapeutic strategies. From the functional point of view walking capacity was proved to be significantly better in the groups of operative treatment compared to non-operative group.

Poor outcomes correlate with the injury pattern of the posterior part of the pelvic ring. Sacral fractures and sacroiliac dislocations result in higher rates of back pain than posterior iliac fracture types (26). The presence of lumbosacral plexus injury correlates to unsatisfactory functional results. Functional results are also affected by poor reduction results and loss of alignment (26,30,31,44). Conversely, it is unusual to obtain a satisfactory functional result in the presence of a fair or poor fracture reduction (26,30).

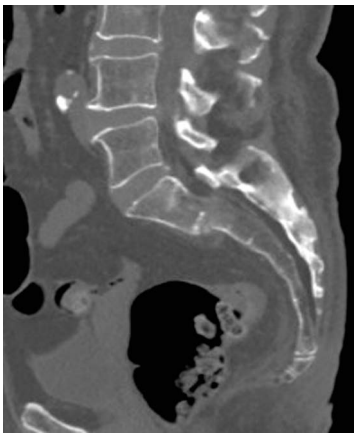
Segmental lumbopelvic fixation is a reliable treatment method for H-shaped sacral fracture with spinopelvic dissociation and it provides sufficient stability for fracture union with a low rate of complications and long-term sequelae (17). In spinopelvic dissociations, quality of reduction in terms of residual postoperative vertical and AP displacements in the vertical sacral fracture lines and translational displacement and kyphosis in the transverse sacral fracture, is associated with the clinical outcome. Accurate reduction of all sacral fracture components is associated with better clinical outcome (17).

Conclusions

High-energy pelvic ring disruptions are relatively uncommon injuries. However, the incidence of FFS seems to be underestimated and the diagnosis is frequently made with delay. Prolonged low back pain or pain in the sacrum area in the elderly, especially if a low-energy trauma has occurred, should raise the suspicion of FFS. CT-scan of the pelvis should be performed early in these cases to get the right diagnosis. Sacral fracture patterns range from vertically stable crush lesions of the lateral sacrum to completely unstable bilateral fractures of the sacrum with spinopelvic dissociation. Various options for management for different type of sacral fractures have been proposed. Iliosacral screw fixation is still the gold standard for the fixation of vertically unstable sacral fractures including FFS. H-shaped sacral fractures, and other possible sacral fracture patterns that occur with spinopelvic dissociations and gross spinopelvic instability, are treated with segmental lumbopelvic stabilization.

2 a)

2 b)



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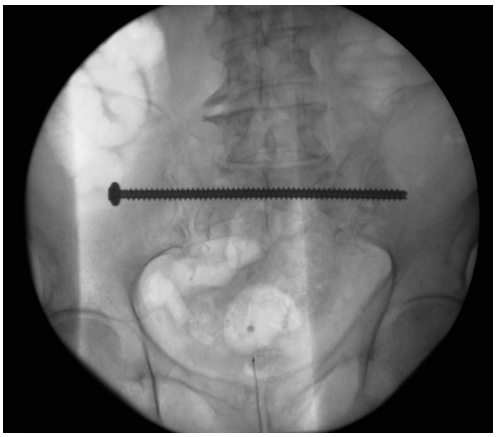

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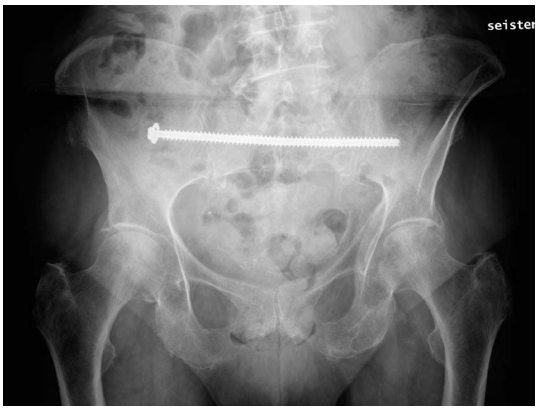

2 e)

2 f)

Figure 2. Treatment of a U-shaped fragility fracture of the sacrum in a 83 year-old female who had a low-energy falling accident. Prolonged pain in the sacrum raised the suspicion of FFS. (a) Pelvis x-ray shows no fracture, but (b-c) CT images two weeks later show a minimally displaced U-shaped sacral fracture. Because the patient was not able to mobilize out of bed during the first two weeks, surgical treatment was performed. (d-e) Pelvis x-ray images and (f) lateral sacral image show a transsacral screw fixation. Two years from the accident, the patient was asymptomatic and was able to walk normally.

References

1. Somersalo A, Paloneva J, Kautiainen H, Lönnroos E, Heinänen M, Kiviranta I. Incidence of fractures requiring inpatient care. Acta Orthop 2014;85:525-530.

2. Ragnarsson B, Jacobsson B. Epidemiology of pelvic fractures in a Swedish county. Acta Orthop Scand 1992;63:297–300.

3. Giannoudis PV, Grotz MR, Tzioupis C, Dinopoulos H, Wells GE, Bouamra O, Lecky F. Prevalence of pelvic fractures, associated injuries, and mortality: The United Kingdom perspective. J Trauma 2007;63:875-883.

4. Matewski D, Szymkowiak E, Bilinski P. Analysis of management of patients with multiple injuries of the locomotor system. Int Orthop 2008;32:753-758.

5. McMurtry R, Walton D, Dickinson D, Kellam J, Tile M. Pelvic disruption in the polytraumatized patient: A management protocol. Clin Orthop Relat Res 1980;151:22-30.

6. Gilliland MD, Ward RE, Barton RM, Miller PW, Duke JH. Factors affecting mortality in pelvic fractures. J Trauma 1982;22:691-693.

7. Tötterman A, Glott T, Madsen JE, Roise O. Unstable sacral fractures. Associated injuries and morbidity at 1 year. Spine 2006;31:E628-E635.

8. Lykomitros VA, Papavasiliou KA, Alzeer ZM, Sayegh FE, Kirkos JM, Kapetanos GA. Management of traumatic sacral fractures: A retrospective case-series study and review of the literature. Injury 2010;41:266-272.

9. Kannus P, Palvanen M, Niemi S, Parkkari J, Jarvinen M. Epidemiology of osteoporotic pelvic fractures in elderly people in Finland: Sharp increase in 1970–1997 and alarming projections for the new millennium. Osteoporos Int 2000;11:443–448.

10. Tosounidis G, Holstein JH, Culemann U, Holmenschlager F, Stuby F, Pohlemann T. Changes in epidemiology and treatment of pelvic ring fractures in Germany: An analysis on data of German Pelvic Multicenter Study Groups I and III (DGU/AO). Acta Chir Orthop Traumatol Čech 2010;77:450–456.

11. Rommens PM, Wagner D, Hofmann A. Surgical management of osteoporotic pelvic fractures: a new challenge. Eur J Trauma Emerg Surg 2012;38:499–509.

12. Wagner D, Ossendorf C, Gruszka D, Hofmann A, Rommens PM. Fragility fractures of the sacrum: how to identify and when to treat surgically?. Eur J Trauma Emerg Surg 2015;41:349–362.

13. Morris RO, Sonibare A, Green DJ, Masud T. Closed pelvic fractures: characteristics and outcomes in older patients admitted to medicaland geriatric wards. Postgrad Med J 2000;76:646–650.

14. Tile M: Fractures of the Pelvis and Acetabulum. Ed 2. Williams & Wilkins, Baltimore 1995.

15. Denis F, Davis S, Comfort T. Sacral fractures: An important problem. Retrospective analysis of 236 cases. Clin Orthop Relat Res 1988;227:67-81.

16. Roy-Camille R, Saillant G, Gagna G, Mazel C. Transverse fracture of the upper sacrum: Suicidal jumper's fracture. Spine 1985;10:838-845.

17. Lindahl J, Mäkinen TJ, Koskinen SK, Söderlund T. Factors associated with outcome of spinopelvic dissociation treated with lumbopelvic fixation. Injury 2014;45:1914-1920.

18. Nork SN, Jones CB, Harding SP, Mirza SK, Routt Jr MLC. Percutaneous stabilization of U-shaped sacral fractures using iliosacral screws: Technique and early results. J Orthop Trauma 2001;15:238-246.

19. Hunt N, Jennings A, Smith M. Current management of U-shaped sacral fractures or spino-pelvic dissociation. Injury 2002;33:123-126.

20. Robles LA. Transverse sacral fractures. Spine J 2009;9:60-69.

21. Gripnau AJG, Boele van Hensbroek PB, Haverlag R, Ponsen KJ, Been HD, Goslings JC. U-shaped sacral fractures: Surgical treatment and quality of life. Injury 2009;40:1040-1048.

22. Yi C, Hak DJ. Traumatic spinopelvic dissociation or U-shaped sacral fracture: A review of the literature. Injury 2012;43:402-408.

23. Rommens PM, Hofmann A. Comprehensive classification of fragility fractures of the pelvic ring: recommendations for surgical treatment. Injury. 2013;44:1733–44.

24. Olson SA, Pollak AN. Assessment of pelvic ring stability after injury. Indications for surgical stabilization. Clin Orthop Relat Res 1996;329:15-27.

25. Lyders EM, Whitlow CT, Baker MD, Morris PP. Imaging and treatment of sacral insufficiency fractures. AJNR. 2010;31:201–10.

26. Lindahl J, Hirvensalo E, Böstman O, Santavirta S. Failure of reduction with an external fixator in the treatment of injuries of the pelvic ring: Long term evaluation of 110 patients. J Bone Joint Surg (Br) 1999;81-B:955-62.

27. Schildhauer TA, Bellabarba C, Nork SE, Barei DP, Routt Jr MLC, Chapman JR. Decompression and lumbopelvic fixation for sacral fracture-dislocations with spino-pelvic dissociation. J Orthop Trauma 2006;20:447-457.

28. Kellam JF: The role of external fixation in pelvic disruptions. Clin Orthop Relat Res 1989;241:66-82.

29. Leighton RK, Waddell JP, Bray TJ, Chapman MW, Simpson L, Martom RB, Sharkey NA. Biomechanical testing of new and old fixation devices for vertical shear fractures of the pelvis. J Orthop Trauma 1991;5:313-7.

30. Lindahl J, Hirvensalo E. Outcome of operatively treated type-C injuries of the pelvic ring. Acta Orthop 2005;76:667-78.

31. Papakostidis C, Kanakaris NK, Kontakis G, Giannoudis PV. Pelvic ring disruptions: treatment modalities and analysis of outcomes. Int Orthop 2009;33:329-338.

32. Gorczyca JT, Varga E, Woodsite T, et al. The strength of iliosacral lag screws and transiliac bars in the fixation of vertically unstable pelvic injuries with sacral fractures. Injury 1996;27:561-564.

33. Zwienen CM, van den Bosch EW, Hoek van Dijke GA, et al. Cyclic loading of sacroiliac screws in Tile C pelvic fractures. J Trauma 2005;58:1029-34.

34. Zwingmann J, Konrad G, Kotter E, Südkamp NP, Oberst M. Computer-navigated iliosacral screw insertion reduces malposition rate and radiation exposure. Clin Orthop Relat Res 2009; 467:1833–1838.

35. Krappinger D, Larndorfer R, Struve P, Rosenberger R, Arora R, Blauth M. Minimally invasive transiliac plate osteosynthesis for type C injuries of the pelvic ring: A clinical and radiological follow-up. J Orthop Trauma 2007;21:595-602.

36. Hao T, Changwei Y, Zhang Q. Treatment of posterior pelvic ring injuries with minimally invasive percutaneous plate osteosynthesis. Int Orthop 2009;33:1435-1439.

37. Dienstknecht T, Berner A, Lenich A, Nerlich M, Fuechtmeier B. A minimally invasive stabilizing system for dorsal pelvic ring injuries. Clin Orthop Relat Res 2011;469:3209-3217.

38. Suzuki T, Hak D, Ziran B, Adams S, Stahel P, Morgan S, Smith W. Outcome and complications of posterior transiliac plating for vertically unstable sacral fractures. Injury 2009;40:405-409.

39. Pohlemann T, Bosch U, Gänsslen A, Tscherne H: The Hannover experience in management of pelvic fractures. Clin Orthop Relat Res 1994; 305: 69-80.25.

40. Gänsslen A, Pape HC, Lehmann U, Lange U, Krettek C, Pohlemann T. Die operative therapie von instabilen sacrum frakturen. Zentralbl Chir 2003;128:40-45.

41. Lindahl J, Hirvensalo E. Transpedikulaarinen fiksaatiolaite pirstaleisten sakrummurtumien hoidossa. Finnish Journal of Orthopaedics and Traumatology 1998;21(3):219-224.

42. Allen BL, Ferguson RL. The Galveston technique for L rod instrumentation of the scoliotic spine. Spine 1982;7:276-284.

43. Sanders D, Fox J, Starr A, Sathy A, Chao J. Trans-sacral-transiliac screw stabilization: Effective for recalcitrant pain due to sacral insufficiency fracture. J Orthop Trauma 2016;30:469-473.

44. Pohlemann T, Gänsslen A, Schellwald O, Culemann U, Tscherne H: Outcome after pelvic ring injuries. Injury 1996;27(Suppl 2):S-B31-38.

Hip Arthrodesis – Is there an option in 2019?

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Introduction

Posttraumatic hip problems can result in significant daily impairments. In the older population group, total hip arthroplasty represents as the gold standard with high rates of pain reduction and good to excellent functional results.

Sometimes, in younger patients, hip joint failure can develop as a result of severe degeneration of the hip joint after acetabular fractures, femoral head necrosis, hip dysplasia and other consequences of hip diseases.

Long-term results of THA in patients < 35 years have been disappointing, with revision rates of 33% to 45% [1-5].

For long-time, hip joint arthrodesis was recommended in younger patients as an alternative to hip replacement, as hip arthrodesis provides adequate pain relief, enables an active lifestyle, and may permit later conversion to THA. Therefore, arthrodesis may be considered as an option.

Effects of Hip Arthrodesis

Liechti analyzed and described the basic principles of hip joint arthrodesis in detail [6].

The optimal position for arthrodesis of the hip joint is not well defined. Thus, the effect of arthrodesis in different positions has to be analyzed to guide for an individual recommendation. The following consequences have to be considered, when deciding for hip arthrodesis. Effect of

- flexion/extension position
- rotational position
- ab-/adduction

A detailed biomechanical understanding is therefore crucial.

Effects of Flexion

Any change in hip position, whether it is flexion or extension, results in some tilting of the whole pelvis. Pelvic tilting, anterior or posterior tilting, results in an unphysiological position of the lumbar spine with a resulting increase or decrease in lordosis. Therefore, adequate flexibility of the lumbar spine has to be tested and clinically analyzed. Any lumbosacral functional impairments can be considered a contraindication for relevant flexion or extended positioning of the femur [6], as from the functional point, unphysiological mobility can result in detrimental complaints.

- effects of 40° of flexion position: it is almost impossible to adequately stand because of the resultant severe lordosis, which increases the load on the non-arthrodesed contralateral side; functionally, a very short non-weight-bearing phase of the gait cycle is present; the main action occurs at the knee level, therefore an intact knee joint is mandatory; relevant lordosis is still present during stepping on the arthrodesed leg; advantages of this position include easy/uneventful climbing stairs and comfortable sitting without severe kyphosis

- effects of 20° of flexion position: this position results in moderate lordosis during standing and marked lordosis by stepping forward with the opposite leg; a physiological lordosis results while weight bearing on the arthrodesed leg; climbing stairs is facilitated by reduction of

lordosis and sitting is comfortable. if adequate kyphosis is possible

- effects of 0° of flexion position: this position allows ideal standing on the arthrodesed leg; if a lumbar lordosis reserve is present, this allows sufficient and adequate contralateral step forward, but the stride length is reduced due to impossible further pelvic reclination; in contrast, climbing stairs becomes difficult and sitting is usually uncomfortable

A (hyper)physiological mobility of the lumbar spine area, the contralateral hip-joint and the ipsilateral knee joint support adequate results of flexion positioning.

Additionally, any flexion position flexion results in some a.p. abduction. It should be considered, that a discrepancy between real and radiographic angles of 2° to 3° has to be expected [6]. From a functional point of view, an individual decision is recommended as

- adequate flexion is important to allow sitting
- extension is better for standing

For planning, the flexion-extension arc of contralateral hip and the lumbar spine motion (40° allows best gait) have to be analyzed.

The 20° flexion position is favored in the young adult, manual laborer who stands most of the time, while a 30-40° flexion position is more recommended for older people, who prefer to sit.

Effects of abduction/adduction

Any unphysiological abduction or adduction results in some lateral tilting of the pelvis which can be compensated by the corresponding curvature of the vertebral column (scoliosis) [6].

It is well known from lower extremity reconstructive procedures, that in a neutral position, the mechanical lower extremity axis is orientated perpendicular to a transverse axis through the pelvis (through the inferior margins of both sacroiliac joints), whereas the anatomic femoral shaft axis has an average angle of 6° adduction to the mechanical axis.

Thus, alignment in the frontal plane has greatest effect on gait because of its relationship to leg length equality [7].

It is supposed, that an adduction position of 3° results in a leg length shortening of 1cm, and an abduction position of 3° in a lengthening of 1cm, respectively.

Overall, some pelvic obliquity is the consequence, which functional consequence is not clearly defined. It is expected, that this results in a tendency to walk slower [8].

Beaulé stated, that arthrodesis in patients with bilateral equal leg length results in an acceptable leg shortening <2cm. A leg length discrepancy of 2-4cm can be compensated by an abduction position, while >4cm should be avoided. In leg length differences of >4cm a two-stage reconstructive procedure should be considered [9].

A resulting abduction/adduction of >6° is associated with a negative effect on the overall outcome [7-9].

Effects of Rotation

Several aspects have to be considered, when addressing rotation hip position:

- arthrodesis in internal rotation results in tripping over the inturned foot and therefore a "lateral" knee flexion
- fixed external rotation increases the load the knee during flexion, but slight exterbnal rotation facilitates putting on and taking off shoes as well as performing routine foot care

Overall, rotational position out if the neutral position can lead to disabling symptoms, especially, if the ipsilateral knee joint presents with an unphysiological function.

Optimal Hip-joint Arthrodesis Position

A too excessive abduction and adduction should be avoided and „playing" with add-/abduction for leg length balancing is recommended.

Due to its negative functional effects, relevant internal rotation positioning should be avoided.

Historically, several authors defined the optimal hip position individually [6, 10-12]:
Watson-Jones (1956) proposed: *30° flexion, 10-15° abduction*
Barmada (1976) proposed: *30° flexion, 10-15° adduction, 5° exterbnal rotation*
Liechti recommended: *15-20° flexion, 0-5° adduction, 0-5° external rotation*
Callaghan (1985) proposed: *35-40° flexion and 5° adduction*

The present recommended optimal positions of hip joint arthrodesis are defined as 20° - 30° flexion, 5° adduction and 5° - 10° external rotation with a minimal leg shortening (within 1 - 1.5 cm) [9].

A recent biomechanical gait analysis in children after hip arthrodesis recommended the 0° rotation of hip fusion as an ideal position, as it allows a better step length of the contralateral hip [13].

Consequences of Hip Arthrodesis

The consequences of hip joint arthrodesis to adjacent joint is of functional relevance. The effect on the ipsilateral knee joint, the contralateral hip joint and the lumbar spine region, as already analyzed, and the effect on gait have to be discussed in detail.

- ipsilateral knee: an intact ipsilateral knee joint is the necessary prerequisite for good functional results; any ankylosis/arthrodesis of the knee absolute contraindication; present degenerative changes often result in inadequate flexion, which is functionally disadvantageous; in cases of existing valgus deformity, this deformity can be increased due to hip arthrodesis and therefore supracondylar osteotomy has to be considered [9]; Hauge et al. reported long-term consequences of hip ankylosis and reported osteoarthritic changes in 65% after 22 years with 51% exhibiting a valgus knee joint [14]

- contralateral hip joint: arthrodesis leads to an increase of the functional load and therefore, perfect clinical results can only be exp0ected in hip joints with full range-of-motion; if flexion is impaired, the hip planned for arthrodesis should be positioned in increased flexion to obtain an adequate stride length; if flexion of the arthrodesed hip is low, this results in some circumduction which can result in painful rotational loading of the mobile hip [9]; in contralateral hips with an arthritic risk a redcuced functional outcome can be expected [15]

- gait disturbsances: arthrodesis results in a shortened stance phase, a prolonged swing phase, shortened step length (results in a slower gait velocity) and an increases stride length; the latter results in a greater anterior pelvic tilt,increased lumbar lordosis and greater flexion/extension excursion of the mobile hip [6]

No hip joint should be performed without adequately analyzing the adjacent joints, e.g. the ipsilateral knee, the contralateral hip and the lumbar spine.

Long-term Consequences

Beaulé et al. summarized the literature and reported on limitations of daily living activities, limitations of sexual activity, problems of ipsilateral knee, problems of contralateral hip and low back problems after hip arthrodesis [9].

Low back pain was observed in 2/3 of patients, ipsilateral knee pain in 35-57% and clinical impairments of the contralateral hip in 19-26% [12, 16]. Recently, three analyses were published:

- an analysis of 34 patients 26-52 years after hip arthrodesis reported on subjective satisfied with an ability to adequately work and perform daily activities, despite ¾ reported on some low back pain, 53% reported on ipsilateral knee pain, 11.8% on contralateral knee pain and 14.7% on contralateral hip pain; low back pain and ipsilateral knee pain appeared late after minimum of 24 years after initial surgery [17]

- Schaffroth et al. reported on long-term results of 30 patients after hip arthrodesis with a mean follow-up of 18.2 years [18]; subjective pain (VAS) was 1.9 for the arthrodesed hip and 2.0 for the contralateral hip, identical values were reported for both knees; low back pain was higher with an average of 3.6; the mean walking capacity was 115 minutes

- Vicente et al. analyzed 56 patients after a mean of 21.6 years and reported on satisfactory results in 85.7%; low back pain was reported in nearly 20% and ipsilateral knee osteoarthritis in 7% [19]

The ideal candidate for hip joint arthrodesis is the young adult with severe monoarticular disease, with no preexisting lumbar, ipsilateral knee or contralateral hip disease and when contraindications are present for THA (active hip-related sepsis). Additionally, it can be a salvage procedure in the multiply operated THA.

Conversion to THA

Later conversion to THA is an option in cases with on-going clinical and functional impairments of surrounding joints [18, 20].

Beaulé et al. summarized the literature up to 2002 and reported on overall good to excellent results after conversion surgery [9].

A relevant improvement of low-back pain of 60-80% and an improvement of knee pain of 40-50% was reported. Overall, a good to excellent functional hip results on the affected hip was observed in a high percentage (60-90%). Recent analyses confirmed these results [21-26].

Overall, good to excellent results can be obtained after conversion of hip arthrodesis to THA with comparable results to primary THA [23]. An increased risk of heterotopic ossifications should be considered [21].

Summary

Hip arthrodesis is still an adequate indication for selected young patients and can result in adequate pain relief for at least two decades. Conversions to THA is a good option after development of clinical failures.

References

1. Schmitz, M., et al., Long-term results of cemented total hip arthroplasty in patients younger than 30 years and the outcome of subsequent revisions. BMC Musculoskelet Disord, 2013. 14:37. doi: 10.1186/1471-2474-14-37.

2. Dorr, L., M. Luckett, and J. Conaty, Total hip arthroplasties in patients younger than 45 years. A nine- to ten-year follow-up study. Clin Orthop Rel Res, 1990. 260: p. 215-219.

3. Ortiguera, C., I. Pulliam, and M. Cabanela, Total hip arthroplasty for osteonecrosis: matched-pair analysis of 188 hips with long-term follow-up. J Arthroplasty, 1999. 14: p. 21-28.

4. Sochart, D. and M. Porter, Long-term results of cemented Charnley low-friction arthroplasty in patients aged less than 30 years. J Arthroplasty, 1998. 13: p. 123-131.

5. Torchia, M., R. Klassen, and A. Bianco, Total hip arthroplasty with cement in patients less than twenty years old. Long-term results. J Bone Joint Surg Am, 1996. 78: p. 995-1003.

6. Liechti, R., Liechti, Hip Arthrodesis and Associated Problems. Springer, Heidelberg, 1978.

7. Ahlbäck, S. and O. Lindahl, Hip arthrodesis. The connection between function and position. Acta Orthop Scand, 1966. 37: p. 77-87.

8. Gore, D., et al., Walking patterns of men with unilateral surgical hip fusion. J Bone Joint Surg Am, 1975. 57: p. 759-765.

9. Beaulé, P., J. Matta, and J. Mast, Hip Arthrodesis: Current Indications and Techniques. J Am Acad Orthop Surg, 2002. 120: p. 249-258.

10. Watson-Jones, R. and W. Robinson, Arthrodesis of the osteoarthritic hip joint. J Bone Joint Surg Br, 1956. 38: p. 353-377.

11. Barmada, R., E. Abraham, and R. Ray, Hip fusion utilizing the cobra head plate. J Bone Joint Surg Am, 1976. 58: p. 541-544.

12. Callaghan, J., R. Brand, and D. Pedersen, Hip arthrodesis. A long-term follow-up. J Bone Joint Surg Am, 1985. 67: p. 1328-1335.

13. Rupcich, M., R. Bravo, and M. Cerrolaza, Biomechanical Analysis of Human Hip in Children with Hip Arthrodesis. Biomed Eng Res, 2013. 2: p. 59-65.

14. Hauge, M., The knee in patients with hip joint ankylosis. Clinical survey and bio-mechanical aspects. Acta Orthop Scand, 1973. 44: p. 485-495.

15. Murphy, S., R. Ganz, and M. Müller, The prognosis in untreated dysplasia of the hip. A study of radiographic factors that predict the outcome. J Bone Joint Surg Am, 1995. 77: p. 985-989.

16. Sofue, M., et al., Long term results of arthrodesis for severe osteoarthritis of the hip in young adults. Int Orthop, 1989. 13: p. 129-133.

17. Kirkos, J., et al., The long-term effects of hip fusion on the adjacent joints. Acta Orthop Belg, 2008. 74: p. 779-787.

18. Schafroth, M., et al., The long-term fate of the hip

arthrodesis: does it remain a valid procedure for selected cases in the 21st century? Int Orthop, 2010. 34: p. 805-810.

19. Vicente, J., et al., Hip arthrodesis: a minimum 20 year follow-up retrospective study. Acta Ortop Bras, 2011. 19: p. 286-288.

20. Bittersohl, B., et al., Hip arthrodesis in the pediatric population: where do we stand? Orthop Rev, 2011. 3:e13.

21. Aderinto, J., et al., Functional results and complications following conversion of hip fusion to total hip replacement. J Bone Joint Surg Br, 2012. 94: p. 36-41.

22. Fernandez-Fairen, M., et al., Is Total Hip Arthroplasty after Hip Arthrodesis as Good as Primary Arthroplasty? Clin Orthop Rel Res, 2011. 469: p. 1971-1983.

23. Peterson, E., et al., Hip Arthroplasty after Previous Arthrodesis. Clin Orthop Rel Res, 2009. 467: p. 2880ß-2885.

24. Villanueva, M., et al., Conversion of Arthrodesis to Total Hip Arthroplasty: Clinical Outcome, Complications, and Prognostic Factors of 21 Consecutive Cases. HSSJ, 2013. 9: p. 138-144.

25. Abdel-Aal, A., H. Bakr, and M. Mahran, Total Hip Arthroplasty for Fused Hips. Orthopedics, 2010. 33: p. 400-404.

26. Rutz, E., D. Schäfer, and V. Valderrabano, Total hip arthroplasty after hip joint ankylosis. J Orthop Sci, 2009. 14: p. 727-731.

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Avoiding axillary nerve injury during minimally invasive plate osteosynthesis of the humeral shaft

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The aims of this study were to clarify the proximity of the axillary nerve (AN) to the osteosynthesis material during minimally invasive plate osteosynthesis (MIPO) of the humeral shaft from a dorsal approach and to evaluate the elongation of the nerve during the performance of MIPO from the transdeltoid approach. In 20 upper extremities from human adult cadavers, a 3.5 mm LCP extra-articular distal humerus plate was inserted through a minimally invasive approach including two incisions. The radial nerve (RN) was depicted and a blunt raspatory was advanced in a proximal direction in order to undermine the AN. Followed by blunt undermining of the triceps muscle, the longest suitable plate was advanced under nerve protection starting from first incision towards proximally and fixed by locking screws. Following dissection, the relation of the AN to the plate and the distance between the AN and the RN were evaluated. In 42 humeri, an 8-, 10- and 12-hole Philos plate (once a straight and once a helically twisted version) were applied from proximal to distal to the bone and the highest distance between the plate and the humerus (plate-bone-distance) was evaluated. The AN lay on the plate in 65%, but was never situated below the plate. The distance between the AN and RN was at a mean of 93.49 mm. In all plate lengths, the helical plates had a statistically significantly lower plate-bone-distance when compared to the straight plates. This technique for humeral shaft MIPO from the dorsal approach proves to be a simple and safe procedure. However, the possible location of the AN on the proximal part of the plate has to be kept in mind and makes dissection of the nerve essential. Further, during MIPO from the ventral approach, pre-contoured twisted Philos plates stretch the axillary nerve significantly less when compared to straight Philos plates.

Introduction

Humeral shaft fractures represent common injuries, concerning approximately 1-3% of all fractures in adults [1-3]. In most of the cases, a conservative regime may be performed however this may lead to non-union rates from 2% up to 23% [4].

For surgical intervention, plate osteosynthesis and antegrade intramedullary nailing represent the most common options. Nevertheless, the optimal treatment regime is still under discussion [4]. Here, open reduction and internal fixation (ORIF) enables the surgeon anatomical reduction. However, this technique requires extensive soft tissue stripping [4-6] and radial nerve (RN) palsies have been reported in up to 17.6% [7]. Further, antegrade intramedullary nailing, although representing a minimally invasive technique [8], may result in iatrogenic

tendon lesions of rotator cuff as well as long head of biceps muscle with postoperative chronic shoulder pain [9-12]. In the last decade, minimally invasive plate osteosynthesis (MIPO) has been popularised as a convenient alternative to the common therapy options. It has resulted in satisfactory outcomes in several clinical studies [2, 7, 8, 13, 14] and enables reduced soft tissue dissection and earlier postoperative mobilisation in comparison to open approaches [2]. Additionally, fewer cases of infection and RN palsies have been reported [4].

Since the current literature mainly focusses on injuries of the RN, the aims of this study were to clarify the proximity of the axillary nerve (AN) to the osteosynthesis material during MIPO of the humeral shaft from a dorsal approach and to evaluate the elongation of the nerve during the performance of MIPO from the transdeltoid approach.

Materials and Methods

Study sample

A total of 20 unpaired upper extremities and 42 dissected humeri from human adult cadavers donated to science, embalmed with Thiel´s method [15, 16], were investigated. All investigated cadavers were donated to the Department of Macroscopic and Clinical Anatomy of the Medical University Graz under the approval of the Anatomical Donation Program of the University of Graz and according to the Austrian law for donations. Exclusion criteria involved evidence of prior interventions or trauma as well as malformations in the area of interest.

Plate Application and measurement pattern during MIPO from the dorsal approach

As the first step, an approximately 4 cm incision was performed at the dorsal side of the lateral epicondyle (LE) followed by blunt undermining of the triceps muscle. Next, a 4 cm long incision was conducted 4 cm distal to the distal border of the deltoid muscle in the line between the apex of the olecranon and the posterior edge of the acromion. The RN and its accompanying vessels were depicted in the interval between the lateral and medial heads of the triceps. In order to undermine the AN, a blunt raspatory was advanced in a proximal direction. A 3.5 mm LCP extra-articular distal humerus plate (Synthes GmbH, Solothurn, Switzerland) was inserted through this minimally invasive approach under protection of the RN from distal to proximal. The plate was advanced proximally under protection of the nerve and was then fixated with two locking screws. A third incision with a length of approximately 4 cm, starting from the distal border of the deltoid muscle in a proximal direction, was conducted. Following splitting of the muscle, the AN was exposed and its relation to the plate was evaluated. Primary, the humeral length (HL) which was defined as the distance between the tip of the greater tubercle and the most distal part of the LE was measured. Next, the performed incisions were connected and the skin and subcutaneous tissues removed. The relationship of the AN to the proximal margin of the plate was examined. Here, it was noted on which plate hole the nerve was located, if applicable. Additionally, the distances between the LE and the AN and between RN and AN were measured.

Elongation tests during the transdeltoid approach

In each of the bones, an 8-, 10- and 12-hole Philos plate (Synthes GmbH, Solothurn, Switzerland) was utilised. Here, the respective plate length was used as a straight and a helical version which was bended at its middle third in a ventral direction in an angle of about 70-90° over a distance of two plate holes. The plates were applied to the humeri from cranial to caudal and the highest distance between the plate and the humerus (plate-bone-distance) was evaluated.

Data analysis

For continuous variables mean and standard deviation (SD), median, minimum and maximum are reported whereas categorical data are described using frequencies and percentages. Spearman's correlation coefficients were used to test possible correlation between HL and the distance between RN and AN. Wilcoxon rank-sum tests were used to test whether there are differences between body sides and the sexes regarding the interval between the nerves. Student's t-tests were utilised for evaluation of differences concerning plate-bone-distance between helical and straight implants. A p-value below .05 was considered statistically significant.

Results

Collective

The collective consisted of 20 unpaired upper extremities (10 right, 10 left) from human adult Caucasian cadavers (11 males, 9 females). Their mean age at time of death was 87.3 years (range 49-96). Since local soft tissues had been removed at the further 42 humeri, gender identification was not possible.

Outcomes of dorsal MIPO

The HL was at a mean of 312 mm (SD 17.9; range: 272-359). Regarding the AN, the nerve was on average located 4.92 mm distal to the proximal border of the plate (SD: 9.63; range: -18.1 [distal to the border] - 14.4 [proximal to the border]) and therefore laid on the plate in 13 specimens (65%; 13/20), see Figure 1. The AN was never located beneath the plate and was situated proximal to the posterior circumflex humeral artery in all specimens. The interval between the LE and the AN was at an average of 257.48 mm (SD 13.67; range: 231.8-286.2). Regarding the distance between the AN and RN, this was at a mean of 93.49 mm (SD 20.0; range: 62.08-127.1). Spearman's correlation coefficients showed that correlation between HL and the distance between RN and AN was not significant ($r = .181$, $p = .446$). Wilcoxon rank-sum tests showed no significant differences concerning gender regarding the interval between the nerves ($W = 60$, $p = .456$), but there seem to be differences between the left and right humeri ($W = 14$, $p = .005$), whereas the interval was smaller in left humeri, however without clinical relevance.

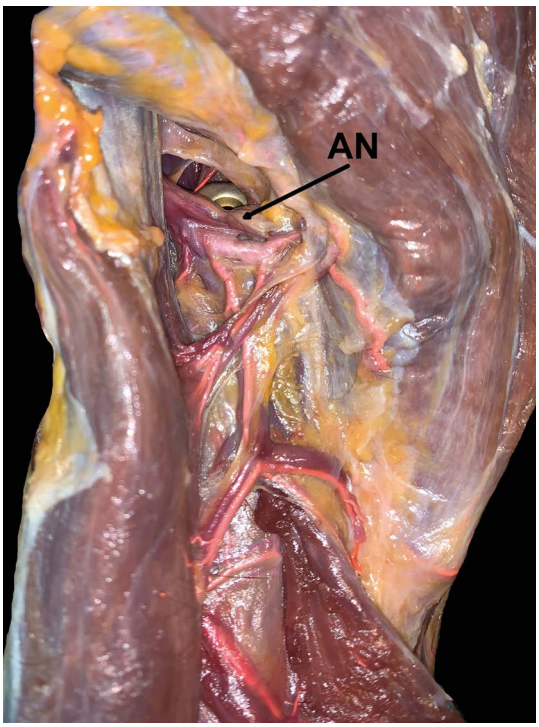

Fig. 1: Axillary nerve (AN) situated on the proximal part of the minimally invasively inserted plate

Outcomes of elongation tests

The mean humeral length (HL) was 291 mm (SD: 17.9; range: 260-350). Regarding all plate lengths, Student's t-test revealed that the helical plates had a statistically significantly lower ($p < .05$) plate-bone-distance (mean: 8.7 mm; SD: 1.7; range: 5.1-14.5) when compared to the straight plates (mean: 11.1 mm; SD: 1.6; rage: 5.9-16.1).

Discussion

The aims of this study were to clarify the proximity of the axillary nerve (AN) to the osteosynthesis material during MIPO of the humeral shaft from a dorsal approach and to evaluate the elongation of the nerve during the performance of MIPO from the transdeltoid approach.

During dorsal MIPO, the AN was on average located 4.92 mm distal to the proximal border of the plate and therefore laid on the plate in 65% (13/20). However, it was never located beneath the plate. The distance between the AN and RN was at a mean of 93.49 mm. For the elongation tests, all plate lengths had statistically significantly lower plate-bone-distances for their helical version when compared to the straight plates.

The tendency to use MIPO instead of common osteosynthesis techniques has become more popular in the treatment of long bone fractures recently. Regarding the humerus, anterior minimally invasive plate application has resulted in satisfactory outcomes in various clinical trials [8, 13, 14]. Further, the proximity of adjacent neural structures during the anterior approach has been evaluated in anatomical studies. Gardner and colleagues [17] found the musculocutaneus nerve to be the main structure

at risk during MIPO and Křivohlávek et al. [18] did not observe any injury to the AN in their dissection study including anterior minimally invasive plating on 24 specimens.

In conclusion, MIPO from the dorsal approach proves to be a simple technique as indicated by our results. However, the mean distance of 93.49 mm between the RN and AN has to be kept in mind. Dissection of the AN is indicated during the use of long implants since the nerve was located directly on the plate in the most cases (65%) in study sample. Further, during MIPO from the ventral approach, pre-contoured twisted Philos plates stretch the axillary nerve significantly less compared to straight Philos plates.

Compliance with ethical standards
Conflict of Interest: The authors declare that they have no conflict of interest.
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References

1. Ekholm R, Adami J, Tidermark J, Hansson K, Törnkvist H, Ponzer S (2006) Fractures of the shaft of the humerus. An epidemiological study of 401 fractures. J Bone Joint Surg Br 88:1469-73. https://doi.org/10.1302/0301-620X.88B11.17634

2. Huri G, Biçer ÖS, Öztürk H, Deveci MA, Tan I (2014) Functional outcomes of minimal invasive percutaneous plate osteosynthesis (MIPPO) in humerus shaft fractures: a clinical study. Acta Orthop Traumatol Turc 48:406-12. https://doi.org/10.3944/AOTT.2014.13.0009

3. Ninck J, Heck S, Gick S, Koebke J, Pennig D, Dargel J (2013) Treatment of proximal humerus fractures: relative position of different locking plates to the axillary nerve. Unfallchirurg 116:1000-5. https://doi.org/10.1007/s00113-012-2242-8

4. Brunner A, Thormann S, Babst R (2012) Minimally invasive percutaneous plating of proximal humeral shaft fractures with the Proximal Humerus Internal Locking System (PHILOS). J Shoulder Elbow Surg 21:1056-63. https://doi.org/10.1016/j.jse.2011.05.016

5. Bell MJ, Beauchamp CG, Kellam JK, McMurtry RY (1985) The results of plating humeral shaft fractures in patients with multiple injuries. The Sunnybrook experience. J Bone Joint Surg Br 67:293-6.

6. Li Y, Wang C, Wang M, Huang L, Huang Q (2011) Postoperative malrotation of humeral shaft fracture after plating compared with intramedullary nailing. J Shoulder Elbow Surg 20:947-54. https://doi.org/10.1016/j.jse.2010.12.016

7. Malhan S, Thomas S, Srivastav S, Agarwal S, Mittal V, Nadkarni B, Gulati D (2012) Minimally invasive plate osteosynthesis using a locking compression plate for diaphyseal humeral fractures. J Orthop Surg 20:292-6. https://doi.org/10.1177/230949901202000305

8. Rancan M, Dietrich M, Lamdark T, Can U, Platz A (2010) Minimal invasive long PHILOS®-plate osteosynthesis in metadiaphyseal fractures of the proximal humerus. Injury 41:1277-83. https://doi.org/10.1016/j.injury.2010.07.235

9. Baltov A, Mihail R, Dian E (2014) Complications after interlocking intramedullary nailing of humeral shaft fractures. Injury 45 (Suppl 1):9-15. https://doi.org/10.1016/j.injury.2013.10.044

10. Lopiz Y, Garcia-Coiradas J, Garcia-Fernandez C, Marco F (2014) Proximal humerus nailing: a randomized clinical trial between curvilinear and straight nails. J Shoulder Elbow Surg 23:369-76. https://doi.org/10.1016/j.jse.2013.08.023

11. Robinson CM, Bell KM, Court-Brown CM, McQueen MM (1992) Locked nailing of humeral shaft fractures. Experience in Edinburgh over a two-year period. J Bone Joint Surg Br 74:558-62.

12. Schwarz AM, Hohenberger GM, Euler S, Weiglein AH, Riedl R, Kuchling S, Krassnig R, Plecko M (2018) Straight proximal humeral nailing: Risk of iatrogenic tendon injuries with respect to different entry points in anatomical specimens. Injury Article in press. https://doi.org/10.1016/j.injury.2018.07.007

13. Oh HK, Cho DY, Choo SK, Park JW, Park KC, Lee JI (2015) Lessons learned from treating patients with unstable multi-fragmentary fractures of the proximal humerus by minimal invasive plate osteosynthesis. Arch Orthop Trauma Surg 135:235-42. https://doi.org/10.1007/s00402-014-2138-x

14. Yang KH (2005) Helical plate fixation for treatment of comminuted fractures of the proximal and middle one-third of the humerus. Injury 36:75-80. https://doi.org/10.1016/j.injury.2004.03.023

15. Thiel W (1992) The preservation of the whole corpse with natural color. Ann Anat 174:185-95 (in German).

16. Thiel W (2002) Supplement to the conservation of an entire cadaver according to W Thiel. Ann Anat 184:267–269 (in German).

17. Gardner MJ, Griffith MH, Lorich DG (2005) Helical plating of the proximal humerus. Injury 36:1197-200. https://doi.org/10.1016/j.injury.2005.06.038

18. Křivohlávek M, Taller S, Lukáš R, Dráč P (2014) Anatomy notes on minimally invasive plate osteosynthesis of the proximal humerus. A cadaver study. Acta Chir Orthop Traumatol Cech 81:63-9.

Kipeä olkapää – Näin tutkin

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Patient history combined with basic clinical examination and plain radiography often provides a preliminary diagnosis accurateenough to initiate treatment of shoulder pain. An injury resulting in severe pain or loss of mobility raises suspicion of a fracture, dislocation or significant tendon injury, which should be diagnosed without delay. Clinical examination includes inspection and palpation as well as assessment of active and passive range of motion. It is rounded up by evaluation of muscle strength and joint stability. A plain radiograph should be taken in all cases involving a significant trauma or prolonged symptoms.

Johdanto

Olkapää on vaivannut jopa joka neljättä suomalaista viimeksi kuluneen kuukauden aikana (1). Olkapääkipu on kaikista tukielinvaivoista kolmanneksi yleisin hoitoon hakeutumisen syy. Vuosittain noin 3 % yli 18-vuotiaista hakeutuu lääkärin vastaanotolle uuden olkapäävaivan vuoksi (2). Olkapotilaan diagnostiikka koetaan usein vaikeaksi. Esitiedoilla, yksinkertaisella kliinisellä tutkimuksella ja natiiviröntgenkuvalla on kuitenkin useimmiten mahdollista päästä oikeaan tai riittävän tarkkaan diagnoosiin, jolloin oikea hoito voidaan käynnistää. Olkapotilasta tutkittaessa on tärkeää tunnistaa tai sulkea pois mahdolliset vakavat ja kiireellistä hoitoa vaativat sairaudet. Päivystyksellisesti tulee todeta muun muassa murtumat, sijoiltaanmenot sekä infektiot ja kiireellisesti (lähetteen kiireellisyysluokitus 8-30 pv) tapaturmaiset jännerepeämät sekä pahanlaatuiset sairaudet. Kiireettömien sairauksien osalta vaivan laatu tulee selvittää riittävän tarkkaan hoidon aloittamiseksi. Tavallisimmat olkasairaudet ovat hyvänlaatuisia. Näitä ovat olkapään jännevaivat, nivelen epävakaus, jäätynyt olkapää ja nivelrikko.

Esitiedot

Kipu on olkaoireista tärkein syy lääkärin vastaanotolle hakeutumiseen. Muita tavallisia oireita ovat sijoiltaanmeno, muljahtelu, liikerajoitus ja voiman heikentyminen. Tyypillisiä olkasairauksia ja niiden oireita on lueteltu taulukossa 1. Oireen alkusyy ja kesto tulee määrittää. Tuoreeseen merkittävään vammaan liittyvä voimakas kipu tai huomattavasti rajoittunut liikelaajuus antavat aiheen epäillä murtumaa, sijoiltaanmenoa tai laajaa jännevauriota, jotka tulee diagnosoida kiireellisesti. Vakavaan sairauteen viittavat varoitusmerkit on esitetty taulukossa 2. Vamman puuttuminen tai kipeytyminen lievän vamman jälkeen viittaa useimmiten rappeumaperäiseen syyhyn.

Esitietoihin kuuluvat myös aikaisemmat sairaudet (erityisesti reuma- ja syöpätaudit, endokrinologiset sairaudet sekä aiemmat tapaturmat ja olkaleikkaukset), elintavat (tupakointi ja alkoholin käyttö), toimintakyky (työ- ja vapaa-aikana), toteutetut hoidot sekä oiretta pahentavat ja helpottavat tekijät (Kuva 1) (3).

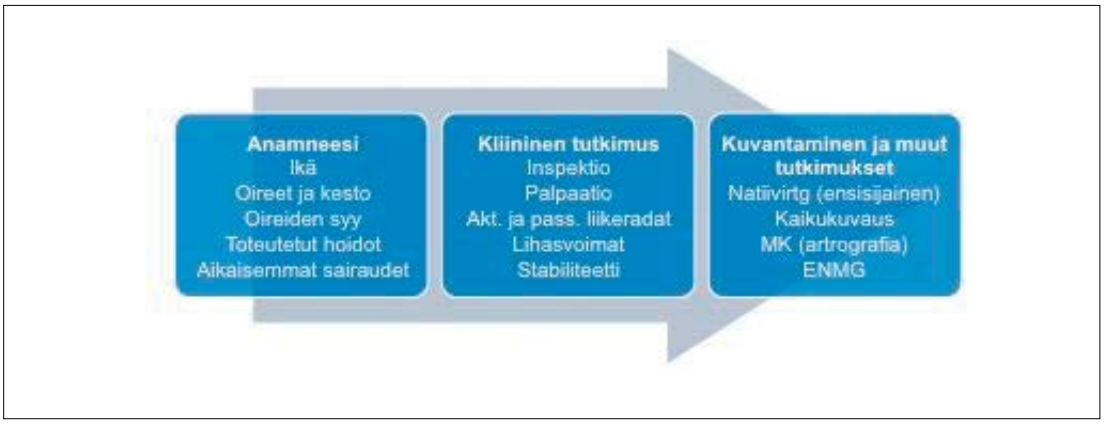
Myös potilaan iällä on merkitystä. Olkanivelen löysyyttä esiintyy yleisimmin nuorilla (alle 30-vuotiailla), ja siihen saattaa liittyä myös olkalisäkkeen alle paikantuva kipu ja pinneoire. Keski-iässä olka-

Taulukko 1. Yleisimmät olkavaivan aiheuttajat sekä tyypilliset oireet ja löydökset (3).

Olkapää	
Kiertäjäkalvosimen jännevaiva	Levossa, rasituksessa tai molemmissa tuntuva kipu, joka paikantuu olkapään tai olkavarren yläosan ulkosyrjän alueelle Rasituskipu ilmenee etenkin vaakatason yläpuolisissa liikkeissä. Läpäisevään repeämään liittyviä oireita ovat lisäksi aktiivisen liikelaajuuden rajoittuminen ja voiman aleneminen.
Jäätynyt olka, nivelkapselin tulehdus, "frozen shoulder"	Oireet vaihtelevat lievästä kivusta lähes sietämättömään kipuun Aktiivisten ja passiivisten liikeratojen rajoittuminen kaikkiin suuntiin, eniten ulkokiertoon. Liikerajoitukset seuraavat kipua joidenkin kuukausien viiveellä. Röntgen ja kaikututkimus usein normaalit
Olkanivelen instabiliteetti	Sijoiltaanmeno tai sen pelko, muljahdustuntemukset
Olkanivelen nivelrikko	Yleensä lievää tai kohtalaista kipua, rutinaa liikkeissä, passiivisen liikeradan rajoitusta, pidemmälle edenneessä nivelrikossa leposärkyä. Röntgen, magneettikuvaus: nivelrikkomuutokset
Olkanivelen artriitti	Tulehdusoireet bakteeriperäisessä ja reumaattisessa tulehduksessa: punoitus, turvotus, kuumotus, kipu Taustalla voi olla leikkaus tai injektio hiljattain. Usein yleisoireita kuten kuumeilua, vilunväristyksiä, huonovointisuutta CRP ja La usein koholla Kaikututkimuksessa ja magneettikuvassa usein artriittiin sopivat löydökset.
Akromioklavikulaarinivelen nivelrikko, kipu	Paikallinen palpaatiokipu Kuvantamistutkimuksissa nivelrikko
Hermopinne tai neuriitti	Kipu, lihasten surkastuminen Deltoideus voi surkastua n. axillariksen vauriossa ja supraspinatus sekä infraspinatus n. suprascapulariksen vauriossa
Olkapäähän liittymätön syy	
Kaularankaperäinen säteilykipu	Radikulaarinen kipu Helpottuu usein kädet ylhäällä ja niskan takana Pahenee kädet alhaalla Kaularangan liikkeet ovat usein rajoittuneet
TOS (rintakehän yläaukeaman pinneoireyhtymä)	Yläraajojen väsyminen ja puutuminen hartiatason yläpuolisissa toimissa
CRPS (alueellinen kipuoireyhtymä)	Raajan kipu ja turvotus, ihon väri- ja lämpötilamuutokset
Pahanlaatuinen kasvain	Patologinen murtuma; yleisoireita, kuten väsymystä, pahoinvointia, laihtumista, kipua Keuhkon kärjessä sijaitsevan syövän (Pancoastin tuumori) oire saattaa olla hartiaseudun särky, yläraajan heikkous ja Hornerin oireyhtymä
Sisäelinperäinen heijastekipu	Sepelvaltimotautiin liittyvä olkakipu pahenee muussakin fyysisessä kuormituksessa kuin yläraajatyöskentelyssä, kuten portaiden nousussa ja ripeässä kävelyssä

Taulukko 2. Olkakipupotilaan varoitusmerkit. Muokattu viitteestä (3).

Merkittävä trauma
Tulehdukseen viittaavat löydökset
Yleisoireet: kuumeilu, yöhikoilu, laihtuminen
Aikaisempi syöpäkasvain tai sen epäily
Olkapään turpoaminen tai selittämätön epämuotoisuus
Äkillinen olkavarren liikkeiden heikkous tai liikelaajuuksien selvä pieneneminen
Epäily heijastekivusta (sydänoireet, hengenahdistus, sappioireet)



Kuva 1. Kliinisen tutkimuksen ja diagnostiikan periaatteet. Muokattu viitteestä (3).

nivelen jännevaivat ja jäätynyt olkapää yleistyvät, ja iäkkäillä nivelrikko ja jännerepeämät ovat tavallisia. On hyvä huomioida, että kiertäjäkalvosimen repeämät ovat iäkkäillä usein oireettomia (4).

Kliininen Tutkimus

Potilasta tutkittaessa keskeisiä ovat olkapään ja lapaluun inspektio ja palpaatio sekä liikelaajuksien, voimien ja stabiliteetin testaaminen. Potilas tutkitaan ylävartalo paljaana. Riisumisen yhteydessä arvioidaan olkapään toimintaa.

Havainnointi. Hartioiden, olkapäiden ja olkavarsien symmetrisyys arvioidaan. Kuoppa hartiassa ylemmän (m supraspinatus) tai alemman lapalihaksen (m. infraspinatus) alueella viittaa kyseisen kiertäjäkalvosimeen liittyvän lihaksen surkastumiseen useimmiten jännevaurion, harvemmin hermosairauden seurauksena. Myös olkanivelen tai olkalisäke-solisluunivelen (AC-nivel) sijoiltaanmeno on usein silmin nähtävissä. ”Kippari-Kallen hauis” osoittaa hauislihaksen pitkän pään jänteen katkenneen. Iäkkäämmillä tähän liittyy usein myös kiertäjäkalvosimen jänteen vaurioituminen.

Lapaluun asento ja liikerytmin poikkeavuudet huomioidaan. Siirottava lapaluu saattaa viitata hermovaurioon tai nivelen löysyyteen. Normaalissa lapa-olkarytmissä olkavarren loitonnus alkaa olkanivelestä ja vasta myöhemmin liikkeeseen tulee mukaan myös lapaluun kierto. Poikkeavalla lapa-olkarytmillä tarkoitetaan sitä, että olkavarren loitonnus tapahtuu lapaluun kiertymisenä epätasaisesti tai normaalia aikaisemmin olkanivelen pysyessä liikkumattomana tai vain vähän liikkuvana. Poikkeava liikerytmi liittyy usein jännevaivaan (kivun aiheuttama liikkeen estyminen tai voiman puute) tai jäykkyyteen (jäätynyt olkapää tai nivelrikko), mutta näillä oireilla ja löydöksillä ei ole aina selvää syy-seuraussuhdetta.

Palpaatiolla voidaan todeta olkalisäke-solisluunivelen oireileva nivelrikko ja epävakaus, vahvistaa havaittu lihaksen surkastumisepäily ja paikantaa akuutin vamman kohta. Muut palpaatiolöydökset ovat epäspesifisempiä, eikä esimerkiksi etuosan palpaatioarkuus ole tunnusomaista millekään tietylle olkasairaudelle. Laaja-alainen olkapään ja hartian alueen palpaatioarkuus viittaa kuitenkin useammin toiminnalliseen tai olkanivelen ulkopuoliseen kuin rakenteelliseen ongelmaan.

Liikelaajuudet asteina ja kivun ilmaantuminen liikkeessä kirjataan etukautta noston ja loitonnuksen yhteydessä. Liikelaajuus arvioidaan goniometrillä tai silmämääräisesti ja sitä verrataan terveeseen puoleen. Uloskiertolaajuus määritetään kyynärpäiden ollessa 90 asteen koukussa kiinni kyljessä. Sisäänkierto määritetään kirjaamalla nikamataso, johon kämmenselkä nousee selkää pitkin. Passiivinen liikelaajuus ja kyky säilyttää asento kädestä irti päästämisen jälkeen (ks. pitotestit jäljempänä) tutkitaan, mikäli todetaan puoliero tai vaje aktiiviliikkeissä. Kipu rajoittaa usein aktiivisia liikkeitä.

Kevyesti liikettä auttamalla saavutetaan usein täysi liikelaajuus, jolloin jäätyneeseen olkapäähän tai nivelrikkoon liittyvä nivelkapselin kireys voidaan

helposti sulkea pois. Nivelkapselin kireyden arviointia voidaan täydentää testaamalla ja vertaamalla sisään- ja uloskiertoa toiseen puoleen 90 asteen loitonnuksessa, jolloin saadaan vielä tarkempi arvio etu- ja takakapselin toiminnasta. Pelkästään aktiivisen liikelaajuuden väheneminen viittaa lihas- tai jänneperäiseen ongelmaan tai kivun aiheuttamaan liikkeen estymiseen.

Lihasvoimat tutkitaan loitonnuksen sekä ulos- ja sisäänkierron osalta toiseen puoleen vertaamalla. Molemmat yläraajat tutkitaan samanaikaisesti. Kivun ilmeneminen testattaessa viittaa kuormitettavan jänteen ongelmaan. Voiman arvioinnissa riittää sanallinen arvio suhteutettuna terveeseen puoleen (normaali ja symmetrinen; lievästi, kohtalaisesti tai voimakkaasti heikentynyt; puuttuu). Voiman heikkous kertoo testatun lihaksen todennäköisestä toimintahäiriöstä: joko vaurioitunut jänne ei välitä voimaa olkaluuhun tai lihas ei supistu. Kivun aiheuttamaa voiman heikentymistä voi kuitenkin olla vaikeaa erottaa todellisesta lihaksen tai jänteen toimintahäiriöstä.

Ylemmän lapalihaksen voima testataan ala-asennossa loitonnuksessa. Alempi lapalihas (m. infraspinatus) jänteineen on olkavarren pääasiallinen uloskiertäjä silloin, kun raaja on vartalon sivulla alhaalla, joten voima testataan tutkijan vastustaessa uloskiertoa kyynärpään ollessa 90 astetta koukistettuna kyljessä kiinni ja kyynärvarren osoittaessa suoraan eteen. Lavanaluslihaksen (m. subscapularis) toimintaa voidaan tutkia luotettavimmin erityistesteillä. Sisäänkiertoon osallistuu useita lihaksia, joten sisäänkierto edellä mainitussa asennossa on epäluotettava minkään yksittäisen sisäänkiertolihaksen testinä. Parhaimpia lavanaluslihaksen testejä on lift off -testi. Jos sisäänkierto on rajoittunut, voi belly press -testi antaa luotettavampaa tietoa (ks. olkapään erityistestit jäljempänä).

Muut asiat. Kainalohermo (n. axillaris) toimii yleensä hyvin, jos ihotunto olkavarren yläosassa ja hartialihaksen (m. deltoideus) jännittyminen loitonnusliikkeessä ovat normaalit. Tarvittaessa, ja aina vamman yhteydesssä, tutkitaan yläraajan distaalisempi sensomotoriikka, verenkierto sekä kaularanka.

Olkapään erityistestit

Erilaisia olkasairauksien diagnosointiin tarkoitettuja testi-tautiyhdistelmiä on kuvattu noin 170 (5). Monen erityistestin positiivisen testituloksen uskottavuusosamäärä (positive likelihood ratio), joka ilmaisee, kuinka moninkertaiseksi testin mittaaman diagnoosin todennäköisyys suurenee, kun testi tai testiyhdistelmä on positiivinen, on lähellä arvoa 1. Tällaisten testien arvo on vähäinen. Mikään yksittäinen testi ole patognomoninen. Parhaiten toimivia ovat olkanivelen apprehensiontesti instabiliteetin diagnostiikassa sekä pitotestit (lag signs) kiertäjäkalvosimen repeämien yhteydessä (6). Yksittäisten testien ohella suositellaan testiyhdistelmiä, koska niillä päästäneen parempaan diagnostiseen osuvuuteen (Taulukko 3) (7). Olkapään jännevaivojen Käypä hoito -suosituksen yhteydestä löytyvät sähköinen tausta-aineisto ja videot (3).

Taulukko 3: Olkadiagnostiikan parhaat testiyhdistelmät (7)

Patologia	***Testiyhdistelmiä***	***LR+***
Kiertäjäkalvosimen repeämä (12)	1 Ikä >65 ja 2 Ulkokiertoheikkous ja 3 Yösärky	10
Kiertäjäkalvosimen repeämä (13) (läpäisevä)	1 Ikä >60 ja 2 Kipukaari ja 3 Drop arm -testi ja 4 Ulkokiertoheikkous	28
Anteriorinen instabiliteetti (14) (traumaattinen)	1 Havahtumistesti ja 2 Relokaatiotesti	40

LR+ = positiivinen ennusteosamäärä; ilmaisee kuinka moninkertaiseksi testin mittaaman diagnoosin todennäköisyys kasvaa testin tai testiyhdistelmän ollessa positiivinen.

Havahtumistesti (apprehensiontesti). Instabiliteettia epäiltäessä luotettavimmaksi on osoittautunut havahtumistesti (apprehension-koe). Testi suositellaan tekemään potilaan maatessa selällään olkapää tutkimuspöydän reunalla. Tutkija kääntää koukistettua kyynärvartta olkavarsi 90 asteen loitonnuksessa rauhallisesti uloskiertoon. Havahtuminen (äkillinen nivelen hallinnan palauttaminen lihasjännityksellä) tai sijoiltaanmenon pelko viittaavat eteenpäin suuntautuvaan epävakauteen. Pelkkä kipu testissä ilman muita oireita ei viittaa epävakauteen eikä ole ”positiivinen havahtuminen” (8).

Relokaatiotesti (anteriorinen instabiliteetti). Havahtumistestiä voidaan täydentää relokaatiotestillä. Mikäli havahtumistesti on positiivinen, uloskierto jää muljahduksen pelon vuoksi usein vajaaksi. Relokaatiotestissa tutkija tukee potilaan olkaniveltä edestä ja uusii tutkimuksen. Testitulos on positiivinen, jos havahtuminen häviää tai sijoiltaanmenon pelko vähenee ja uloskiertolaajuus lisääntyy (8).

Uloskierron pito -testi (ylempi ja alempi lapalihas). Tällä testilla tutkitaan uloskiertäjien toimivuus. Tutkija pitää potilaan kyynärpään suorassa kulmassa ja olkavarren 20 asteen loitonnuksessa. Sen jälkeen tutkija vie olkanivelen maksimaaliseen passiiviseen uloskiertoon ja päästää kädestä irti (potilaan kyynärpää tuetaan edelleen toisen käden avulla). Tutkittavan kyvytto¨myys pita¨a¨ uloskiertoasento viittaa alemman lapalihaksen toimimattomuuteen: joko lihas ei supistu tai kiertäjäkalvosimessa on sen alueelle ulottuva vaurio (8).

Lift off testi ja sisäänkierron pito testi (lavanaluslihas). Potilas vie käden vartalon taakse vyötärön tasolle ja pyrkii työntämään kättään irti vartalosta tutkijan vastustaessa liikettä. Testillä arvioidaan lavanaluslihaksen voimaa. Tässä asennossa tehdään myös sisäänkierron pito -testi, jossa käsi pidetään irti selästä. Päästäessään otteensa tutkija pyytää potilasta pitämään tämän asennon. Kyvyttömyys pitää asento viittaa lavanaluslihaksen toimimattomuuteen tai sen jännerepeämään (8).

Belly press testiä (lavanaluslihas) suositetaan, jos lift off -testin suorittaminen ei onnistu olkanivelen rajoittuneen sisäänkierron vuoksi. Potilas pitää kyynärnivelen suorassa kulmassa ja painaa kämmenellä vatsaansa eli tekee aktiivisen sisäänkierron kyynärpään osoittaessa suoraan sivulle. Testi on positiivinen ja viittaa lavanaluslihaksen repeämään, mikäli kyynärpää pettää taaksepäin, ranne koukistuu ja voima on heikentynyt, kun tutkija yrittää vetää kättä irti vatsalta (8).

Pinneoire (ylempi lapalihas) liittyy usein kiertäjäkalvosinongelmaan. Testissä olkalisäkkeen alainen kipu esiintyy tyypillisesti aktiivisessa loitonnuksessa voimakkaimmiltaan noin 60 ja 120 asteen välilla (8).

Drop arm (ylempi lapalihas). Tutkija nostaa potilaan yläraajan passiivisesti maksimaaliseen loitonnukseen. Otteen päästäessään tutkija pyytää potilasta hitaasti laskemaan yläraajan. Kyvyttömyys suorittaa liike hallitusti (yläraajan asento pettää tai ”tippuu”) viittaa ylemmän lapalihaksen jänteen repeämään (8). Sekä pinneoireen tarkistaminen että drop arm -testi saadaan ”kaupanpäällisinä”, kun testataan loitonnusliikelaajuus.

Cross arm- ja cross body testit (olka lisäke-solisluunivel). Cross arm -testissä tutkija seisoo potilaan vieressä tutkittavan olkapään puolella, tukee olkapäätä yhdellä kädellä ja kyynärpäätä toisella. Olkanivel asetetaan passiivisesti 90 asteen koukistukseen ja kyynärpäätä painetaan vastapuolen olkapäätä kohti. Kyynärpään lähestyessä vastakkaista olkapäätä potilaalta tiedustellaan kiputuntemuksia olkalisäke-solisluunivelen alueella (olkalisäke-solisluunivelrikko) ja tarkkaillaan solisluun pään paikallaan pysymistä (olkalisäkesolisluunivelen instabiliteetti). Cross body -testissä tutkittava tekee vastaavan liikkeen itse (8).

Edellä mainittujen testien lisäksi löytyy lukuisia muita testejä. Usein käytettyjä ovat esimerkiksi Hawkinsin ja Neerin (pinne)testit, mutta niiden diagnostinen arvo ei ole edellä mainittuja testejä parempi.

Kuvantaminen

Diagnostiikkaa täydennetään tarvittaessa kuvantamistutkimuksilla ja neurofysiologisilla tutkimuksilla (ENMG). Olkapäädiagnostiikan perustutkimus on natiiviröntgenkuvaus, joka tehdään aina, mikäli oireen alkuun liittyy merkittävä tapaturma tai oire on pitkittynyt yli 3-4 viikon mittaiseksi. Tutkimuksen tarkoituksena on osoittaa merkittävät olkanive-

len ja olkalisäke-solisluunivelen rappeumamuutokset, vammalöydökset (murtumat ja sijoiltaanmenon liittyvät) sekä sulkea pois muut luupoikkeavuudet (verenkiertohäiriöt, kasvaimet). Röntgenkuvassa näkyvällä olkalisäkkeen muodolla (”koukkumainen akromion”) ei ole selkeää syy-yhteyttä olkasairauksiin (9). Kiertäjäkalvosin ei näy röntgenkuvassa, mutta kiertäjäkalvosimen poikkeavuus voidaan toisinaan todeta epäsuorasti, jos olkaluun pää on noussut nivelkuoppaansa nähden ylös (viittaa laajaan korjauskelvottomaan kiertäjäkalvosimen repeämään) tai jos olkalisäkkeen alla näkyy pehmytkudoskalkkiumia (joita löytyy oireettomilta liki yhtä usein kuin oireisilta).

Kiertäjäkalvosinta ja monia muita olkapään alueen pehmytkudoksia voidaan suoraan tutkia kaiku- ja magneettikuvauksella. Kaikukuvauksen diagnostiikkaan ja hoitolinjan valintaan tuoma lisäarvo kliiniseen tutkimuksen lisänä on kokemuksemme mukaan vähäinen. Kokeneen radiologin tekemän kaikukuvauksen tarkkuus on kuitenkin arvioitu hyväksi (näytönaste B) (3). Esimerkiksi lihasatrofioiden arviointi sillä on kuitenkin mahdotonta. Kaikukuvaajan kokemuksen ja harjaantuneisuuden merkitys on suuri. Kaikukuvausta ei tule tehdä ilman edeltävää röntgenkuvausta.

Mikäli diagnoosi on huolellisen tutkimuksenkin jälkeen epävarma tai suunnitellaan leikkausta, voi kyseeseen tulla magneettikuvaus, jonka tekemistä suositellaan vain olkasairauksien hoitoon perehtyneen lääkärin lähetteestä, yleensä erikoissairaanhoidossa. Magneettikuvaus on tutkimusmenetelmistä monipuolisin. Se näyttää kiertäjäkalvosinjänteiden ja lihasten kunnon ohella hyvin myös luisen avulsion, rustorenkaan ja nivelsiteiden vammat, nivelen tulehdusmuutokset, luun ja pehmytosien kasvaimet sekä murtumat ja luuruhjeet esimerkiksi nivelen sijoiltaanmenon jäljiltä. Magneettikuvauksessa voidaan käyttää nivelen sisään ruiskutettavaa tehosteainetta (magneettiartrografia), jolloin herkkyys ja tarkkuus rustorenkaan ja nivelsidevammojen sekä ei-läpäisevien kiertäjäkalvosinrepeämien toteamisessa paranee.

Tietokonetomografia (TT) on paras olkapään alueen luurakenteiden tutkimus. Varjoainetehosteista TT-artrografiaa voidaan käyttää myös kiertäjäkalvosimen tai labrum-ligamenttikompleksin diagnostiikassa, jos magneettikuvaus ei onnistu potilaan ahtaan paikan kammon tai muun vasta-aiheen vuoksi.

Kuvantamistuloksen arvioinnissa on hyvä pitää mielessä, että poikkeavat kuvantamislöydökset ovat yleisiä oireettomassa väestössä. Esimerkiksi läpäisevien kiertäjäkalvosinrepeämien esiintyvyys 60-vuotiailla on 25 % ja 80-vuotiailla 50 %, ja olkalisäke-solisluunivelrikon esiintyvyys alle 30-vuotiailla 68 % ja yli 30-vuotiailla 93 % (10) (11). Kuvantamistutkimuksessa tehty poikkeava löydös on merkityksellinen yleensä vain, jos se on yhdistettävissä potilaan oireeseen.

Muita tutkimuksia

ENMG:tä tarvitaan olkasairauksien diagnostiikassa melko harvoin. Sitä voidaan tarvita yläraajan hermopunoksen, kainalohermon, lavanpäällyshermon (n. suprascapularis) tai pitkän rintahermon (n. thoracicus longus) vauriota epäiltäessä. Tutkimuksella on merkitystä myös erotusdiagnostiikassa.

Laboratoriokokeet ovat tarpeellisia harvoin, lähinnä epäiltäessä tulehduksellista tai infektiivistä nivelsairautta.

Lopuksi

Oireisen olkapään tutkiminen on helppoa ja nopeaa. Perustutkimusten ensisijaisena tavoitteena on todeta tai sulkea pois kiireellistä hoitoa vaativat vakavat sairaudet. Esitiedoilla ja yksinkertaisella kliinisellä perustutkimuksella sekä natiiviröntgenkuvauksella saadaan usein riittävästi tietoa. Tällöin voidaan aloittaa oireenmukainen tai sairauteen kohdennettu hoito ja arvioida erikoissairaanhoidon lähetteen tarvetta.

Viitteet

1. Koskinen S, Lundqvist A, Ristiluoma N. Terveys, toimintakyky ja hyvinvointi Suomessa 2011 2012.

2. Artus M, van der Windt DA, Afolabi EK, Buchbinder R, Chesterton LS, Hall A, et al. Management of shoulder pain by UK general practitioners (GPs): a national survey. BMJ Open. 2017;7(6):e015711.

3. Lepola V, Paloneva J, Huuskonen ML, Kallinen M, Karppinen J, Mattila K, et al. [Update on current care guidelines. The tendon disorders of the shoulder]. Duodecim. 2015;131(2):194-5.

4. Minagawa H, Yamamoto N, Abe H, Fukuda M, Seki N, Kikuchi K, et al. Prevalence of symptomatic and asymptomatic rotator cuff tears in the general population: From mass-screening in one village. J Orthop. 2013;10(1):8-12.

5. Hanchard NC, Lenza M, Handoll HH, Takwoingi Y. Physical tests for shoulder impingements and local lesions of bursa, tendon or labrum that may

accompany impingement. Cochrane Database Syst Rev. 2013;4:CD007427.

6. Hegedus EJ, Goode A, Campbell S, Morin A, Tamaddoni M, Moorman CT, 3rd, et al. Physical examination tests of the shoulder: a systematic review with meta-analysis of individual tests. Br J Sports Med. 2008;42(2):80-92; discussion

7. Hegedus EJ, Cook C, Lewis J, Wright A, Park JY. Combining orthopedic special tests to improve diagnosis of shoulder pathology. Phys Ther Sport. 2015;16(2):87-92.

8. Magee DJ. Orthopedic Physical Assessment. Sixth edition. Elsevier Saunders. 2014.

9. Moor BK, Wieser K, Slankamenac K, Gerber C, Bouaicha S. Relationship of individual scapular anatomy and degenerative rotator cuff tears. J Shoulder Elbow Surg. 2014;23(4):536-41.

10. Yamamoto A, Takagishi K, Osawa T, Yanagawa T, Nakajima D, Shitara H, et al. Prevalence and risk factors of a rotator cuff tear in the general population. J Shoulder Elbow Surg. 2010;19(1):116-20.

11. Stein BE, Wiater JM, Pfaff HC, Bigliani LU, Levine WN. Detection of acromioclavicular joint pathology in asymptomatic shoulders with magnetic resonance imaging. J Shoulder Elbow Surg. 2001;10(3):204-8.

12. Litaker D, Pioro M, El Bilbeisi H, Brems J. Returning to the bedside: using the history and physical examination to identify rotator cuff tears. J Am Geriatr Soc. 2000;48(12):1633-7.

13. Park HB, Yokota A, Gill HS, El Rassi G, McFarland EG. Diagnostic accuracy of clinical tests for the different degrees of subacromial impingement syndrome. J Bone Joint Surg Am. 2005;87(7):1446-55.

14. Farber AJ, Castillo R, Clough M, Bahk M, McFarland EG. Clinical assessment of three common tests for traumatic anterior shoulder instability. J Bone Joint Surg Am. 2006;88(7):1467-74.

Virtual Reality and Orthopedics

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Virtual Reality (VR) is a computer generated simulated environment. VR has been around for decades but only recently technological advances have made it eligible for broader consumer distribution. The main reason is the development of affordable high quality VR head mounted displays (HMDs). This could open doors for VR to establish itself as a tool for surgical planning and training.

As described by Niklaus F. Friederich, there are three common problems educators and training surgeons in these days are facing. First, the tightening of work hour restrictions for surgical residents, that are lowering the amount of surgical procedures performed during residency. In addition, the growing expectation of patients on surgery outcomes and thereby unwillingness to serve as a training object for residents. And finally, the growing expenses of healthcare, that force us to optimize the usage of OR time, which limits possibility for training (1).

Surgical simulation training has one clear goal: Acquisition of surgical skills outside of the operating theatre.

According to a meta-analysis by McGaghie et al, simulation-based training is more effective than traditional clinical medical education in achieving specific clinical skill acquisition goals (2). In another study Konradsen et al have shown, that virtual reality simulators are particularly useful for training cognitive and psychomotor skills (3).

In addition to acquisition of surgical skills outside of the operating theatre it is essential, that these skills are also transferable to the operating theatre.

A systematic review by Dawe et al. of laparoscopic cholecystectomy and endoscopy simulator studies showed, that surgical skills acquired through simulation-based training are transferable to the operating theatre (4). Furthermore, a study by Boza et al. found that simulation-trained junior residents performed better than general surgeons on advanced laparoscopic cases (5).

In addition to a healthy self-esteem, it is widely known, that the basis for extraordinary surgical skills is solid knowledge of human anatomy. Thereby it is important, that anatomy is taught in the most intuitive way from the very beginning. A recent study by Weyhe et al indicates, that a 3D virtual reality environment might be a more intuitive and effective way to acquire anatomy knowledge than books. (6)

As we can see, it is still too early to say what the effect on patient and learning outcomes will be, but there is research evidence from different fields indicating that VR can be a feasible option, especially in the area of surgical training, when comparing to traditional methods.

References

1. Niklaus F. Friederich - Simulation in (Orthopaedic) training, Editorial, Journal of Arthroscopy and Joint Surgery 2018;5;1;1-2

2. McGaghie, W. C., Issenberg, S. B., Cohen, E. R., Barsuk, J. H., & Wayne, D. B. Does simulation-based medical education with deliberate practice yield better results than traditional clinical education? A meta-analytic comparative review of the evidence. Academic medicine: journal of the Association of American Medical Colleges, 2011;86(6), 706-11.

3. Jensen, L., & Konradsen, F. A review of the use of virtual reality head-mounted displays in education and training. Education and Information Technologies, 2018;23(4), 1515-1529.

4. Dawe, S. R., Pena, G. N., Windsor, J. A., Broeders, J. A. J. L., Cregan, P. C., Hewett, P. J., & Maddern, G. J. Systematic review of skills transfer after surgical simulation-based training. British Journal of Surgery, 2014;101(9), 1063-1076.

5. Boza, C., León, F., Buckel, E., Riquelme, A., Crovari, F., Martínez, J. & Varas, J. Simulation-trained junior residents perform better than general surgeons on advanced laparoscopic cases. Surgical endoscopy, 2017;31(1), 135-141.

6. Weyhe D., Uslar V., Weyhe F., Kaluschke M., Zachmann G. Immersive Anatomy Atlas-Empirical Study Investigating the Usability of a Virtual Reality Environment as a Learning Tool for Anatomy. Front Surg. 2018;30;5:73

Deformed Knee and Osteoarthritis: How to Treat?

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A non-balanced mechanical axis in lower extremity may cause early osteoarthrosis (OA) in the knee. Valgus deformity leads easily to lateral and varus deformity to medial OA. Rotational abnormalities may harm the extensor mechanism. Deviation in sagittal plane is maybe the deformation best tolerated by the knee but even it may cause problems in everyday physical activities.

Many different conditions may cause deformations in the knee joint or in the extra-articular areas in the femur or in the tibia. Post-traumatic situations are the most common: malunited fracture can cause marked imbalance in the knee thus leading in early OA. Osteochondrodysplacias constitute a rare but diverse group of hereditary developmental bone diseases. They are the most common reason for dwarfism. Many of them cause bending in the long bones and thus imbalance and secondary OA in the knee. Other non-traumatic reasons for severe deformities are, e.g. hypophosphatemia, osteogenesis imperfecta, and hypoplacia of the leg.

If the knee joint is compromized by a secondary severe OA and walking is painful and difficult, arthroplasty of the knee is the best treatment option. There are three approaches to correct the deformity and OA:

1. Arthroplasty without any extra bone operations with maximal correction of the mechanical imbalance and deformity;
2. Osteotomy or osteotomies of the deformed bone/bones and arthroplasty of the joint in one or in two operations;
3. Arthroplasty using a custom-made special knee prosthesis which corrects the axis and the OA.

Arthroplasty without other bone operations is good option when the deformity is in or near the knee joint and maximum of 15-20, in tibia even more degrees in mechanical axis (1). This kind of correction is, in most cases, possible without compromising the functional result of the operation. Of course, it requires quite an extensive release of the soft tissues of the concave side of the knee. And for low demand, physically inactive patients, reasonable imbalance in the mechanical axis can be accepted. This kind of modified primary arthroplasty is a "difficult primary" operation and the recovery after operation is quite quick, comparable to that of standard arthroplasty.

Correction of the deformed bone to straighten the axis and an arthroplasty is good option when there is marked extra-articular deformity in femur and/or in tibia, especially if the deformity is in two or three planes. Often long stems of the components can be used as intramedullary nails to fix the osteotomy. An extra plate may be needed for rotational stability but after (long) healing the mechanical axis is more or less straight and the knee joint function is normal. (2) Figure 1 A, B

Custom-made implants designed with three-dimensional digital planning software can correct severe mechanical imbalance and OA at the same time. A custom-made prosthesis is a good option in extra- or intra-articular deformities especially if there is also a suspicion of the collateral ligament stability (3-5). The stress and long recovery time caused by double operation (correction osteotomy and arthroplasty) may be difficult and even a severe risk for some patients; customized implants are easier and a less painful option. Technically customized arthroplasty is quicker to do, which decreases risk of infection and costs at the operating theatre. Individually planned custom-made implants themselves are much more expensive than basic knee implants. Figure 1 A, C

It is important to plan arthroplasty of a deformed knee well. Arthroplasty with standard components is good option in many cases, especially for

the low-demand patients. Osteotomy and arthroplasty is an excellent option when a severe two- or three dimensional deformity has to be corrected for a high-demand patient. In many cases, a customized implant makes the otherwise challenging operation easier because the correction is already in-built in the implant.

A. *B.* *C.*

Figure 1.
A. 45-y female, juvenile idiopathic arthritis. Secondary OA, extra-articular deformities in femurs and in tibias
B. Right side: A double-osteotomy and a long-stemmed standard TC-3 type prosthesis were operated in one-stage operation. Recovery went well but lasted up to 6 months.
C. Left side: A customized hinge prosthesis was implanted. Recovery was uneventful and shorter, about 2 months.

References

1. Wang JW, Wang CJ: Total knee arthroplasty for arthritis of the knee with extra-articular deformity. J Bone Joint Surg Am. 2002; 84-A(10):1769-74.

2. Lonner JH, Siliski JM, Lotke PA: Simultaneous femoral osteotomy and total knee arthroplasty for treatment of osteoarthritis associated with severe extra-articular deformity. J Bone Joint Surg Am. 2000; 82(3):342-8.

3. Kim RH, Scuderi GR, Dennis DA, Nakano SW: Technical challenges of total knee arthroplasty in skeletal dysplasia. Clin Orthop Relat Res. 2011; 469:69-75.

4. Sewell MD, Hanna SA, Al-Khateeb H, et al: Custom rotating-hinge primary total knee arthroplasty in patients with skeletal dysplasia. J Bone Joint Surg Br. 2012; 94:339-343.

5. Nuutinen T, Både K, Ristolainen L, Kauppinen H, Madanat R, Manninen M. Yksilöllisesti suunnitellut polviproteesit anatomisissa poikkeustilanteissa. Suom Ortop Traumatol 2018; 41 (2): 94-96.

Hemofiilinen artropatia

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Haemophilia is an inherited x-chromosomally linked bleeding disorder affecting males. It is caused by Factor VIII (haemophilia A) or Factor IX (haemophilia B) deficiency. In addition, a number of even more rare forms of disease with deficiency of other coagulation factors are known (II, V, VII, X, XI, XIII). Another particular subgroup consists of so-called inhibitor patients who have developed antibodies against coagulation products.

The prevalence varies internationally being approximately 1-2: 10 000 in haemophilia A and 1:30 000 in haemophilia B. Without proper replacement therapy haemophilia can lead to permanent joint damage, haemophilic arthropathy. It can also cause other life- or quality-of –life threatening bleedings. Often the normal bleeding is prolonged or can reappear in few days, and massive bleeds are more uncommon. On the other hand, even a minor operation such as joint puncture can cause severe complications without adequate replacement therapy.

The mechanisms of joint damage are not fully understood, but typical findings include haemosiderosis, ie iron accumulation, activation of inflammatory cells, increased production of cytokines and enzymes, and possible direct cartilage destruction caused by them. Arthropathy can be associated with typical deformities or extensive bone defects.

Haemophilia is treated by intravenous administration of FXIII or FIX either regularly as a primary prophylaxis after the first year of age or after primary bleed as a secondary prophylaxis. On-demand treatment is also possible if the bleeding disorder is mild. Replacement therapy is expensive, and it also accounts for at least 60% of the total cost of arthroplasty treatment. In case of inhibitors involved, the coagulation system must be bypassed with either activated prothrombin complex (aPCC) or recombinant activated factor VII (rFVIIa). The problem with these preparations is that they are still much more expensive than usual replacement therapy. The actual treatment of antibody formation is the immune-tolerance induction therapy (ITI), in which the patient is exposed to daily clotting factor doses for several months, even years. If successful, it will reduce both morbidity and cost.

The most common target joints are elbows, knees, ankles and hips, but all joints can be affected. As therapies evolve, hemophilic secondary arthritis has started to resemble more normal primary arthrosis. On the other hand, haemophilic ankle arthropathy is an increasing problem, possibly due to increased loads already provided by better treatments during adolescence.

Synovitis caused by recurrent joint bleed is visible by ultrasound and can be used to support the assessment of treatment response. Bleeding problems of a single joint can be treated with conventional synovectomy or so-called radiosynovectomy using a radioactive Holmium isotope. Treatment of severe secondary arthritis of the knee and hip is a joint replacement when conservative treatment fails to respond, as in the cases of elbow and shoulder joint. The severe haemophilic arthropathy of the ankle is traditionally treated with arthrodesis.

However, arthroplasty of the ankle can be performed if the movement of the joint is to be maintained.

The importance of multidisciplinary teamwork is emphasized in the operative care of a haemophilia patient. In severe arthropathy, bone defects, and deformities may require special prosthesis, bone grafting or augmentation. Multiple joint problems are common and different exercise restrictions should be taken into account in the design of the treatment. Prior to surgery, the hematologist plans an individual treatment and research plan based on the patient's bleeding profile. Here, there is a need for a dialogue between the surgeon and the hematologist about the extent and duration of the procedure. The patient's response to replacement therapy may vary, and rapid changes in bleeding status are possible. Therefore, availability of laboratory tests is important also outside office hours. New types of subcutaneously administered preparations are revolutionizing the traditional intravenous treatment of haemophilia patients. These include FVIII-mimicking emicizumab as well as concizumab and fitusiran, which inhibit anti-coagulation mechanisms. However, as the treatments continue to improve and change, the challenge is to ensure their safe use and proper monitoring. Taking into account the specificity of the treatment, it is essential that these operations are centralized in a professional unit.

Hemofilia on harvinainen x-kromosomaalisesti periytyvä verenvuotosairaus joka periytymistapansa vuoksi ilmenee miehillä, naiset ovat kantajia. Uudet mutaatiot ovat mahdollisia ja erittäin harvinaisissa geenimuutoksissa myös nainen voi sairastaa hemofiliaa. A-hemofiliassa veren hyytymisjärjestelmä toimii puutteellisesti hyytymistekijä VIII (FVIII) vajeen vuoksi ja B-hemofiliassa on kyse hyytymistekijä IX (FIX) vajeesta. Lisäksi tunnetaan joukko vielä harvinaisempia tautimuotoja, joissa ilmenee muiden hyytymistekijöiden vajetta (II, V, VII, X, XI, XIII). Hyytymisen seulontakokeet P-tromboplastiiniaika (TT) ja aktivoitu partiaalinen tromboplastiiniaika (P-APTT) paljastavat kliinisesti tärkeitä sairauksia, joten seulontakokeiden spontaanit poikkeavuudet on aina syytä selvittää.

Laborotoriolöydösten ja vuotoprofiilin perusteella hemofilia voidaan jakaa vaikeaan, keskivaikeaan ja lievään tyyppiin. A-hemofilia on useimmilla potilailla vaikea, kun taas B-hemofiliapotilailla taudin muoto on useimmin keskivaikea/lievä. Suomessa vajaa 400 potilasta sairastaa hemofiliaa, pääosin (n.2/3) A-hemofiliaa. Hoidon kehittyessä, spontaanimutaatioiden lisääntyessä ja kuolleisuuden vähentyessä, viimeisten vuosikymmenien aikana hemofiliapotilaiden määrä on kasvanut 1,7-kertaiseksi. A-hemofilian prevalenssi keskimäärin on 1-2:10000 ja B-hemofilian 1:30000. Hoitamattomana tauti johtaa vakaviin verenvuotoihin erityisesti nivelissä, mutta myös arvaamattomat sisäelin- ja aivoverenvuodot ovat mahdollisia. Tyypillistä on, että hemofiliassa verenvuoto pitkittyy ja siten aiheuttaa kudostuhoa ja huonoa paranemista ilman nopeaa hemostaasin hallintaa spesifisillä hyytymistekijävalmisteilla. Toisaalta pienikin toimenpide, kuten polvipunktio voi aiheuttaa vakavia ongelmia ilman asianmukaista hyytymiskorvaushoitoa. Samoin 2-3 vrk.n sisällä ilmaantuvat jälkivuodot ovat hemofilialle tyypillisiä.

Hemofilian hoito

Toistuvat vuodot nivelissä johtavat niveltuhoon, hemofiiliseen artropatiaan. Nivelen vaurioitumismekanismeja ei tunneta täydellisesti, mutta tyypillisiä löydöksiä ovat hemosideroosi eli raudan kertyminen, tulehdussolujen aktivoituminen, sytokiinien ja entsyymien lisääntynyt tuotanto ja niiden mah-

Kuva 1. Hemofiilinen artropatia

dollisesti aiheuttama suora rustotuho. Lapsuudessa vakavia vuotoja epifyysilinjoihin saaneilla potilailla esiintyy sekundääriartropatian lisäksi myös tyypillisiä deformiteetteja (esimerkiksi polven fleksio-tai valgusdeformiteetit, Kuva 1). Niveltuhoon voi liittyä laajoja luupuutoksia tai intraosseaalisia verenvuodon aiheuttamia hemofiliakystia. Tämän lisäksi toistuvat vuodot pehmytkudoksiin saattavat aiheuttaa lihasten arpeutumista johtaen lopulta fleksiokontraktuuraan, jolloin nivelen liukupintojen korjaaminen ei enää riitä korjaamaan nivelen toimintaa mutta voi auttaa kipuun. Suuri verenvuoto esim. psoaslihakseen voi aiheuttaa aitiopainetta ja hermovaurion, ja ns. pseudotuumorien kehittyminen on mahdollista.

Hemofiliaa hoidetaan antamalla hyytymistekijää (FVIII tai FIX) suonensisäisesti joko säännöllisesti primääriprofylaksiana ensimmäisen ikävuoden jälkeen (keskuslaskimoportin kautta, nykykäytäntö) tai ensimmäisten vuotojen jälkeen sekundääriprofylaksiana (aiempi käytäntö, ennen 1990-lukua). Myös 'on demand'-tyyppinen tarvittaessa annettava hoito on mahdollista esim. jos vuototauti on lievä, mutta hoito annetaan aina operaation tai trauman yhteydessä vaikkei vuotoa olisi ehtinyt kehittyä. Maissa, joissa hoitoresurssit ovat niukat, tämän tyyppiseen hoitoon joudutaan turvautumaan vaikeankin hemofilian hoidossa (1). Hyytymiskorvaushoito on kallista, ja myös tekonivelleikkauksissa se muodostaa vähintään 60% koko hoidon kustannuksista riippumatta siitä, tarvitaanko esim. erikoiskomponentteja tai samanaikainen molemminpuolinen toimenpide(2). Erityisryhmän hoidon kannalta muodostavat ns. inhibiittoripotilaat (A- tai harvemmin B-hemofiliaa sairastavat), joilla on kehittynyt neutraloivia vasta-aineita annettua hyytymiskorvaushoitoa kohtaan (3, 4). Heillä perinteiset hyytymiskorvausvalmisteet eivät toimi vaan vuodon sattuessa hyytymisjärjestelmä täytyy ohittaa joko aktivoidulla protrombiinikompleksivalmisteella (activated prothrombin complex concentrate, aPCC) tai rekombinantti faktori VII valmisteella (rFVIIa). Nämä valmisteet ovat tavallista korvaushoitoakin vielä huomattavasti kalliimpia. Vasta-ainemuodostuksen varsinainen hoito on siedätysterapia (immuno-tolerance induction, ITI), jossa potilas altistetaan päivittäisille hyytymistekijäannoksille muutamien kuukausien, jopa parin vuoden ajan. Onnistuessaan (n. 70%) siedätyshoito vähentää merkittävästi sairastuvuutta sekä kustannuksia. Potilaalta vaaditaan pitkällistä sitoutumista, mutta terveystaloushyöty saavutetaan muutaman vuoden kuluessa.

Vuotojen kannalta tavallisimmat kohdenivelet ovat kyynärnivelet, polvet, nilkat ja lonkat, mutta vuotoja voi tulla kaikkiin niveliin. Hoitojen kehittyessä vakavimmat niveltuhot ja kasvun häiriintyminen on nykyisin Suomessa harvinaista ja hemofiilinen sekundääriartroosi on alkanut muistuttaa enemmän normaalia primääriartroosia. Toisaalta hemofiilinen nilkan artropatia on lisääntyvä ongelma, johtuen parempien hoitojen mahdollistamasta lisääntyneestä kuormituksesta jo nuoruusiällä ja valitettavasti osin ylipainon lisääntymisestä.

Toistuvien nivelvuotojen aiheuttama synoviitti havaitaan ultraäänellä, ja sitä voidaan käyttää hoitovasteen arvioimisen tukena. Yksittäisen nivelen toistuvia vuotoja voidaan hoitaa perinteisellä synovektomialla tai ns. radiosynovektomialla, käyttäen radioaktiivista Holmium-isotooppia. Polven ja lonkan vaikean sekundaariartroosin hoito on tekonivelleikkaus, jos konservatiivisella hoidolla ei saavuteta riittävää vastetta, samoin kyynärnivelen ja olkanivelen kirurgiaa voidaan harkita (5-8). Nilkan vaikea hemofiilinen sekundaariartroosi on perinteisesti hoidettu artrodeesillä (9). Artrodeesi voi kuitenkin kuormituksen muuttuessa johtaa viereisten nivelten kulumiseen. Vaihtoehtona rajatuissa tapauksissa voidaan tehdä nilkan artroplastia, mikäli nivelen liike halutaan/on mahdollista säilyttää (10).

Hoidon erityispiirteitä ja nykykehitystä

Hemofiliapotilaan operatiivisessa hoidossa korostuu moniammatillisen tiimityön merkitys. Vaikeassa artropatiassa luupuutokset, kystat ja deformiteetit

saattavat vaatia erikoisproteesin, luusiirteitä tai augmenttien käyttöä. Hematologi suunnittelee ennen leikkausta potilaan vuoto- ja laboratorioprofiiliin perustuen yksilöllisen hoito- ja tutkimussuunnitelman, joka kattaa pre- ja perioperatiivisen (1.-7. postoperatiivisten päivien) korvaushoitosuunnitelman, verikokeet ja jatkoseurannan ja kuntoutuksen vaatimukset. Tässä tarvitaan vuoropuhelua ortopedin ja hematogin välillä toimenpiteen laajuudesta ja kestoarviosta sekä oletetusta leikkausvuodosta normaalitilanteessa, ja tarvittaessa akuutisti. Perusperiaatteena on 100-120% hyytymistekijäaktiviteetti preoperatiivisesti, ja sen pitäminen n. 50-80% tasolla seuraavat 1-5 vrk, kliinisen arvion mukaan. Traneksaamihapon käyttö hyödyttää hyytymiskorvaustuotteiden ohella, tukosprofylaksia ei tarvita ellei ole kyse erityistilanteesta (esim. syöpään liittyvä ortopedia). Vaste korvaushoidolle voi vaihdella kuten potilaan vuototilannekin. Erityisesti inhibiittoripotilailla mahdollinen vasta-ainemuodostuksen aktivoituminen voi muuttaa hemostaasia nopeasti. Vuototilanteet on osattava tunnistaa ajoissa ja verinäytteiden helppo saatavuus on tärkeää myös virka-ajan ulkopuolella. Fysioterapia ja mobilisaatio on ajoitettava hyytymisen kannalta optimaalisesti. Samoin hyytymisen optimoimiseksi kylmähauteita suositellaan välttämään ja kuntoutustoimet ajoitetaan korvaushoidon ensitunneille. Kipulääkityksenä hemofiliapotilailla voidaan käyttää koksibeja. Usean nivelen samanaikaiset ongelmat ovat tyypillisiä ja erilaiset liikuntarajoitteet tulee huomioida hoidon suunnittelussa.

Hyytymiskorvausvalmisteita on markkinoilla runsastuva valikoima, mutta valtaosassa tarvitaan 2-3 viikossa suonensisäinen annostelu, joka edellyttää hyvää hoitokomplianssia. Uudentyyppiset subkutaanisti annosteltavat valmisteet ovat mullistamassa hemofiliapotilaiden perinteistä vuotoja ehkäisevää ylläpitohoitoa. Näitä ovat FVIII funktiota imitoiva emisitsumabi sekä antikoagulaatiomekanismeja estävät consitsumabi ja fitusiraani. B-hemofiliassa on saatu ensimmäisiä lupaavia tuloksia geeniterapialla(1, 11).

Hemofiliahoitojen jatkuvasti parantuessa ja muuttuessa haasteena on varmistaa niiden turvallinen käyttö ja oikeanlainen monitorointi; esimerkiksi vaikutusaika eri valmisteissa voi vaihdella muutamasta tunnista kokonaiseen kuukauteen. Hoidon erityispiirteet huomioiden tulevaisuudessakin hemofiliapotilaiden hoito tulisi keskittää tarvittavat resurssit omaavaan yksikköön, jossa on monialainen toimintakulttuuri. Fysioterapian integraatio on tärkeä osa tätä toimintaa.

Viitteet

1. Peyvandi F, Garagiola I, Young G. The past and future of haemophilia: diagnosis, treatments, and its complications. Lancet. 2016;388(10040):187-97.

2. Danielson H, Lassila R, Ylinen P, Yrjonen T. Total joint replacement in inhibitor-positive haemophilia: Long-term outcome analysis in fifteen patients. World J Orthop. 2017;8(10):777-84.

3. Wight J, Paisley S. The epidemiology of inhibitors in haemophilia A: a systematic review. Haemophilia : the official journal of the World Federation of Hemophilia. 2003;9(4):418-35.

4. Vepsalainen K, Lassila R, Arola M, Huttunen P, Koskinen S, Ljung R, et al. Inhibitor development in previously untreated patients with severe haemophilia A: a nationwide multicentre study in Finland. Haemophilia : the official journal of the World Federation of Hemophilia. 2016;22(5):721-9.

5. Rodriguez-Merchan EC, Jimenez-Yuste V, Gomez-Cardero P, Alvarez-Roman M, Martin-Salces M, Rodriguez de la Rua A. Surgery in haemophilia patients with inhibitors, with special emphasis on orthopaedics: Madrid experience. Haemophilia : the official journal of the World Federation of Hemophilia. 2010;16(102):84-8.

6. Jenkins PJ, Ekrol I, Lawson GM. Total knee replacement in patients with haemophilia: the Scottish experience. Scott Med J. 2013;58(4):223-7.

7. Westberg M, Paus AC, Holme PA, Tjonnfjord GE. Haemophilic arthropathy: long-term outcomes in 107 primary total knee arthroplasties. Knee. 2014;21(1):147-50.

8. Thomason HC, 3rd, Wilson FC, Lachiewicz PF, Kelley SS. Knee arthroplasty in hemophilic arthropathy. Clin Orthop Relat Res. 1999(360):169-73.

9. Tsailas PG, Wiedel JD. Arthrodesis of the ankle and subtalar joints in patients with haemophilic arthropathy. Haemophilia : the official journal of the World Federation of Hemophilia. 2010;16(5):822-31.

10. Asencio JG, Leonardi C, Biron-Andreani C, Schved JF. Short-term and mid-term outcome of total ankle replacement in haemophilic patients. Foot Ankle Surg. 2014;20(4):285-92.

11. Arruda VR, Doshi BS, Samelson-Jones BJ. Novel approaches to hemophilia therapy: successes and challenges. Blood. 2017;130(21):2251-6.

The posterior interosseous nerve during three common approaches to the proximal radius

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The posterior interosseous nerve (PIN) is a structure at risk during the volar, lateral and posterior approaches to the proximal radius. The aim of the study was to evaluate the nerve's close relationship to these approaches during forearm rotation. The study collective consisted of 90 upper limbs. The ventral approach to the proximal radius was performed, and the distance between the Arcade of Frohse (AF) and the radial border of the distal biceps tendon (DBT) was measured in maximum supination and pronation. After performance of the lateral approach, the distance between the tip of the radial head and the PIN's exit point from the supinator (= distance 1) and the shortest interval between the nerve's exit to the radial margin of the ulna (= distance 2) were measured in maximum pronation and supination. Then the dorsal approach was conducted and again distance 1 and the interval between the distal margin of the anconeus and the nerve's exit point (distance 2) were evaluated (pronation and supination). During the ventral approach, the distances between the DBT and the AF were significantly shorter during pronation in comparison to supination. There were significantly shorter distances during supination in comparison to pronation during the lateral and dorsal approaches. Detachment of the supinator is indicated in maximum supination during the ventral approach to the proximal radius. Supination needs to be avoided during the lateral and dorsal approaches to the proximal radius in order to avoid PIN injury.

Introduction

Fractures of the radial head and neck account for approximately 1.4-4% of all fractures, respectively 33% of all elbow fractures. Here, the treatment options for non-dislocated fractures have changed from a mostly performed non-operative approach including stabilization by cast to early motion which correlates with good functional outcomes. Indications for surgical reconstruction obtain primary unstable or secondary dislocated radial head fractures as well as open fractures. However, dislocated fractures frequently occur in combination with elbow dislocation and injury to the medial and lateral collateral ligaments. Regarding their management, the surgical gold standard (open reduction and internal fixation versus radial head arthroplasty) remains controversial. [18]

Here, the ventral, lateral and posterior approaches represent commonly performed approaches. The ventral approach is performed through a skin incision on the volar aspect of the forearm. Access is gained through the interval between brachioradialis and pronator teres in order to reach the distal biceps tendon (DBT) and the supinator. During the lateral approach, access to the proximal radius is gained through the interval between the anconeus and the extensor carpi ulnaris after skin incision alongside

the radial aspect of the proximal forearm. After elevation of these muscles, the radial head can be depicted following incision of the joint capsule. During the dorsal approach, the skin incision is drawn alongside the posterior aspect of the ulna. Afterwards, the anconeus is elevated in a lateral direction to gain access to the radial head and neck. [1, 10]

The posterior interosseous nerve (PIN) is a structure at risk during all of these approaches. The aim of the study was to evaluate the nerve's close relationship to these approaches during forearm rotation.

Material & Methods

Sample composition

The sample consisted of 90 upper limbs (45 right and 45 left) from human adult cadavers which had been embalmed by use of Thiel's solution [19]. Exclusion criteria were severe arthrosis and visual evidence of prior surgeries or trauma.

Dissection protocol

The ventral approach to the proximal radius was performed, the radial nerve was exposed in the interval between the brachialis and brachioradialis muscles and its pathway was traced to the Arcade of Frohse (AF). The elbows were placed in maximum extension and the distance between the AF and the radial border of the DBT was measured in maximum supination and pronation.

After performance of the lateral approach to the proximal forearm in typical manner, the PIN's exit from the supinator was depicted. Here, care was taken not to manipulate the nerve's original course. The elbows were positioned in 90 degrees flexion and the following points of interest were measured in maximum supination, respectively maximum pronation:

1. The distance between the tip of the radial head and the PIN's exit point from the supinator (= distance 1)
2. and the shortest interval between the nerve's exit to the radial margin of the ulna (= distance 2).

As the next step, the dorsal approach to the proximal radius was performed and direct sight on the PIN was gained. Starting from this approach, the following distances were measured:

1. The interval between the PIN's exit point from the supinator to the tip of the radial head (= distance 1)
2. as well as the distance between the distal margin of the anconeus and the nerve's exit point (distance 2).

Additionally, the radial length (RL), which was defined as the distance between the radial styloid process and the top of the radial circumference (in neutral position) was evaluated. All measurements were taken by use of a digital calliper rule and recorded in millimetres.

Statistical analysis

The collected data were analysed using the statistical software R [14]. For descriptive statistics mean, standard deviation, median, minimum and maximum are presented. Differences of the respective measurements (ventral approach: distance between the AF and the radial border of the DBT; lateral approach: position 1 and 2; dorsal approach: position 1 and 2) were investigated using paired t-tests. A p-value < .05 was regarded as statistically significant.

Results

The sample involved 90 extremities gained from 29 (64%) male as well as 16 (36%) female adult human cadavers. Donor's age ranged from 49 to 99 years with a median of 86. The mean RL was 233.7 mm (SD 19.7; range: 194-283). During the ventral approach, the distances between the DBT and the AF were significantly shorter ($p < .001$) during pronation (right side: 14.1±3.4; left side: 13.5±3.2) in comparison to supination (right side: 20.5±3.6; left side: 19.8±3.5). Regarding the lateral approach, distance 1 changed from a mean of 60.3 mm (supination) to 62.7 mm in pronation ($t = 11.911$, $df = 49$, $p < .001$). Distance 2 (lateral approach) revealed the most impressive interval change with 4.7 mm in supination and 11.2 mm in pronation ($t = 15.750$, $df = 49$, $p < .001$). Here, the PIN was situated directly on the radial margin of the ulna in twelve cases (in-

terval = 0 mm). For the dorsal approach, distance 1 decreased from 62.9 mm (pronation) to 60.2 mm (supination) which also proved to be statistically significant ($t = 11.940$, $df = 49$, $p < .001$). Further in distance 2 the values were at a mean of 26.1 mm (pronation) and 19.3 mm (supination), respectively ($t = 13.729$, $df = 49$, $p < .001$).

Discussion

The goal of our study was to evaluate the PIN's close relationship to the ventral, lateral and dorsal approaches to the proximal radius during forearm rotation.

During the ventral approach, the distances between the DBT and the AF were significantly shorter during pronation when compared to supination. For the lateral and dorsal approaches, all of the measured intervals became significantly shorter during supination in comparison to pronation. Regarding the lateral approach, the PIN even lay directly on the radial border of the ulna in 24% at position 2 during supination. These results are comparable to the study of Heidari and colleagues [9]. Authors performed measurements on 20 cadavers and found a significant increase of the distance between the lateral cortex of the ulna at a distance of 30 mm from the articular surface of the radial head and the PIN in pronation (mean: 22.3 mm) when compared to supination (mean: 12.3 mm).

The PIN represents the longest branch and furthermore the continuation of the deep branch of the radial nerve [5]. Following division of the radial nerve into its superficial branch and the PIN the latter gains entrance to the supinator channel through the Arcade of Frohse (Figure 1). During its course to the wrist joint, the whole extensor musculature of the forearm is innervated by its fibres [12, 19]. After perforating the supinator at variable height, the nerve continues its course between the superficial and deep extensor compartments of the forearm [20]. Its first provided muscular branches are recurrent fibres from its ulnar aspect that reach the extensor digitorum. Next, two branches from the underside of the PIN course to the extensor carpi ulnaris and the extensor digiti minimi, respectively. Via these ramifications, the superficial layer of the extensor musculature is completely innervated. Concerning the supply of the deep extensors, the PIN delivers a branch shortly distal to its exit point from the supinator. This divides on the one hand into fibres running in a distal direction, supplying the extensor pollicis brevis and the abductor pollicis longus, and on the other hand into a recurrent branch to the superficial layer of the supinator. A further muscular fibre courses between the extensor pollicis longus and the extensor indicis while supplying both of these muscles. After emitting these branches, the PIN mostly transverses the abductor pollicis longus and the extensor pollicis brevis, while innervating these muscles. During its course on the forearm, the nerve is covered by the extensor pollicis longus. Further on, the nerve reaches the IOM where it is accompanied by the dorsal trunk of the anterior interosseous artery and can be traced in a distal direction to the wrist joints, contributing to their sensory nerve supply [6, 7].

As a result of its critical location, radial head or neck fractures may lead to PIN palsy. [1,2,8] Further,

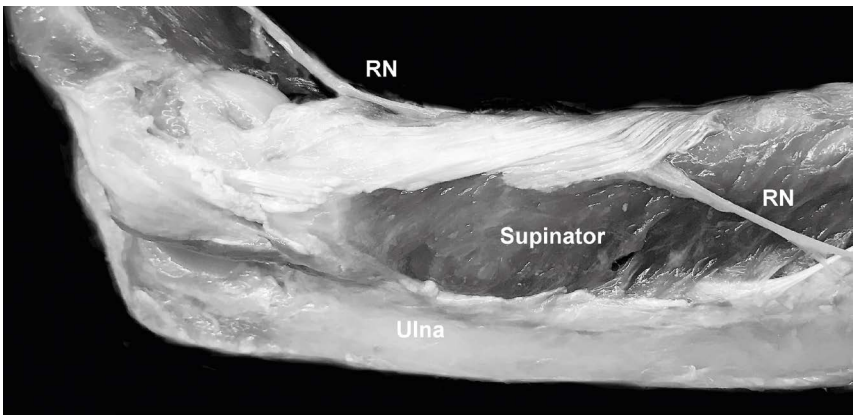

Figure 1: The PIN inside of the supinator

the nerve may be injured intraoperatively during all available approaches [8, 11, 17]. Here, the risk is increased in cases of fractures, tumours, inflammation and alteration of the common anatomy [4, 13, 16]. Additionally, the PIN may be traumatised during arthroscopic procedures at the elbow [3].

In this study, we found that maximum forearm supination increases the interval between the DBT and the PIN statistically significant. Therefore, we indicate detachment of the supinator in maximum supination during the ventral approach to the proximal radius. Further, we evaluated a statistically significant shorter distance between the exit point of the PIN and all our chosen anatomical landmarks during supination which leads to the conclusion that supination during the lateral and dorsal approaches to the proximal radius needs to be avoided in order to protect the nerve.

Compliance with ethical standards

Conflicts of interest: The authors declare that they have no conflict of interest.
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References

1. AO Foundation (2017) AO Surgery Reference. https://aotrauma.aofoundation.org/Structure/education/self-directed-learning/reference-materials/ao-surgery-reference

2. Artico M, Telera S, Tiengo C, et al. (2009) Surgical anatomy of the radial nerve at the elbow. Surg Radiol Anat 31:101-6.

3. Bhatia DN, Das Gupta B, Panjwani T (2016) Cadaveric study of anterior and posterior elbow endoscopy portals for endoscopic distal biceps repair: comparative anatomy-at-risk. Surg Radiol Anat 38:781-91.

4. Diliberti T, Botte MJ, Abrams RA (2000) Anatomical considerations regarding the posterior interosseous nerve during posterolateral approaches to the proximal part of the radius. J Bone Joint Surg Am 82:809-13.

5. Dubert T, Oberlin C, Alnot JY (1990) Anatomie des nerfs articulaires du poignet. Application à la technique de dénervation. Ann Chir Main Memb Super 9:15-21.

6. Elgafy H, Ebraheim NA, Rezcallah AT, Yeasting RA (2000) Posterior interosseous nerve terminal branches. Clin Orthop Relat Res 376:242-251.

7. Elgafy H, Ebraheim NA, Yeasting RA (2000) The anatomy of the posterior interosseous nerve as a graft. J Hand Surg Am 25:930-935.

8. Hackl M, Wegmann K, Lappen S, Helf C, Burkhart KJ, Müller LP (2015) The course of the posterior interosseous nerve in relation to the proximal radius: is there a reliable landmark? Injury 46:687-92. https://doi.org/10.1016/j.injury.2015.01.028

9. Heidari N, Kraus T, Weinberg AM, et al. (2011) The risk injury to the posterior interosseous nerve in standard approaches to the proximal radius: a cadaver study. Surg Radiol Anat 33:353-7.

10. Hoppenfeld S, deBoer P, Buckley R (200). Surgical Exposures in Orthopaedics - The anatomic approach, 4th edition. Philadelphia, Lippincott Williams & Wilkins, p:122-137.

11. Kelly EW, Morrey BF, O'Driscoll SW (2000) Complications of repair of the distal biceps tendon with the modified two-incision technique. J Bone Joint Surg Am 82-A:1575-81.

12. Loh YC, Stanley JK, Jari S, Trail IA (1998) Neuroma of the distal posterior interosseous nerve. A cause of iatrogenic wrist pain. J Bone Joint Surg Br 80:629-630.

13. Mekhail AO, Ebraheim NA, Jackson WT, Yeasting RA (1996) Anatomic considerations for the anterior exposure of the proximal portion of the radius. J Hand Surg Am 21:794-801.

14. R Core Team (2016) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: https://www.R-project.org/

15. Raeburn K, Burns D, Hage R, et al. (2015) Cross-sectional sonographic assessment of the posterior interosseous nerve. Surg Radiol Anat 37:1155-60.

16. Schimizzi A, MacLennan A, Meier KM, Chia B, Catalano LW 3rd, Glickel SZ (2009) Defining a safe zone of dissection during the extensor digitorum communis splitting approach to the proximal radius and forearm: an anatomic study. J Hand Surg Am 34:1252-5. https://doi.org/10.1016/j.jhsa.2009.04.026

17. Strauch RJ, Rosenwasser MP, Glazer PA (1996) Surgical exposure of the dorsal proximal third of the radius: how vulnerable is the posterior interosseous nerve? J Shoulder Elbow Surg 5:342-6.

18. Tejwani NC, Mehta H (2007) Fractures of the radial head and neck: current concepts in management. J Am Acad Orthop Surg 15:380-7.

19. Thiel W (1992) The presentation of the whole corpse with natural color. Ann Anat 174:185-95.

20. Wada T, Ogino T, Usui M, Ishii S (1997) Distal posterior interosseous nerve syndrome. Handchir Mikrochir Plast Chir 29:129-32.

Mild traumatic brain injury

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Traumatic brain injury (TBI) is either a temporary disturbance of the brain function or a permanent damage to the structure of the brain, in both cases caused by an external force. The most common cause for TBI in the developed countries is a ground level fall, and a remarkable number of patients are under the influence of alcohol. Possible intracranial damages which require immediate (surgical) treatment are detected or ruled out by computer tomography (CT) scan. Furthermore, it is essential during the first contact with the patient to recognize and record the clinical symptoms and signs as well as the mechanism of the injury. For example, the time of the possible amnesia cannot be determined a week later and the recognition of a possible unconsciousness requires a witness.

Most of the TBIs are mild and a good recovery can be expected in weeks or months. The recovery is more predictable if the information about the injury and symptoms, as well as the good prognosis, are available (1).

The term concussion refers to the mildest form of TBI, mTBI, when there is the immediate, but transient symptoms(s) of a TBI, and thus the symptoms reflect a functional disturbance rather than a structural injury seen on the standard structural neuroimaging studies.

Sports related concussion

Sports related concussion (SRC) may be caused either by a direct blow to the head or elsewhere on the body with an impulsive force transmitted to the head. As in any concussion, it typically results in a rapid onset of short-lived impairment of neurological function that resolves spontaneously. Similarly to ”normal” concussion, the prognosis is very good. However, there are some important and special issues related to SRC that need attention. These include the possible harmful effect of repetitive concussions during an athlete's career, the possible need for rest vs. training during the recovery, and the timing of the return to play. Finally, as after any concussion, there is a question of how best to help the minority of patients who have prolonged symptoms.

Increased risk for dementia?

In 2012 it was reported that former NFL players (n=3439, playing at least five seasons between 1959 – 1988) had an increased risk for neurodegenerative disease (2). By comparing standardized mortality ratios (SMR) between the ex-players and normal population, the researchers concluded that there ”should have” been four deaths because of neurodegenerative disease among the ex-players, but there were as many as ten deaths (+6). This suggests that the risk indeed for these players clearly increased. On the other hand, there ”should have” been 630 deaths among the ex-players, but there were only 334 deaths, thus ”saving” 290 lives (630 – 334 – 6) by playing as professional as compared to the normal population, even taking into account the extra six players died because of neurodegenerative disease. Since the season played started already in 1959, years before the invention of CT scanner, it is likely that not all injuries at the time were concussions, but rather contusions known to have a bigger risk for neurodegenerative disease later in life (3). On the other hand, mTBI does not seem to increase the risk for dementia or cognitive impairment later in life (4).

Chronic traumatic encephalopathy

Especially in the USA the possibility of former collision sports athletes for developing a chronic, progressive neurodegenerative disease, often termed as

chronic traumatic encephalopathy (CTE), has raised tremendous interest. CTE, which some researchers especially before 2015 believed to be a progressive neurodegenerative disease which can be triggered even by one mTBI, is a rare neuropathological, post-mortem diagnosis with no established or validated criteria. Whereas some researchers still believe in CTE as a specific diagnosis, it is now established that the neuropathology of CTE is present in people with other neurodegenerative diseases. Also, there are very few cases of CTE diagnosed despite the huge amount of athletes involved in contact sports. The symptoms claimed to be caused by CTE, such as depression, are common in normal population. Further, there is only minimal scientific evidence to support the progressive nature of the diagnosis (5). Therefore, CTE is probably not the major worry after an SRC. In fact, it may even have negative iatrogenic effects to "diagnose" or warn about a progressive neurodegenerative disease in someone with a psychiatric illness due to entirely other factors.

According to some studies the patients who present at the ER after a minor head trauma have a clearly diminished life expectancy compared to the normal population (6). This, at the first sight, might support a theory of a kind of a progressive disease triggered by a minor head trauma. However, the excess mortality is thought to be caused by the same reason that caused the accident in the first place, alcohol. Obviously, alcohol does not play a common role in SRCs, but is not totally non-existent among retired athletes.

Need for "brainrest"?

Clinicians especially in the USA have recommend strict physical and cognitive rest after a concussion. Rest has been described as "the cornerstone of treatment" after a concussion. The theory behind this is that the concussed brain is in a vulnerable state placing it at an increased risk of delayed recovery should it sustain more trauma. Whereas it seems clear that in contact sports the risk for new injury is increased if a player continues playing in an altered state of consciousness, the scientific basis for the need to restore the brains metabolic homeostasis by total rest is not as clear. In fact, the idea of the need for "brainrest" has never been widely accepted in Finland. The need for "brainrest" has lately been widely challenged (7). An active recovery and training after concussion has recently been encouraged, and the benefit of sub-symptom threshold aerobic training program as compared to the treatment as usual has been demonstrated among pediatric athletes despite of temporary (<24h) symptom exacerbations (8).

After SRC – to play or not to play?

The latest consensus statement about concussion in sports was published in 2017 (9). In brief, it recommends that when a player shows any symptoms or signs of an SRC, he should be removed from the field and assessed by a healthcare provider. After the first-aid, an assessment of the concussion should be made using the SCAT5 (or similar) sideline assessment tool which typically takes about 10 minutes. A player with a diagnosed SRC should not be allowed to return to play on the day of the injury. The consensus statement supports the idea that after an SRC the player probably should take it easy and rest according to his feelings for a day or two, but after that he should gradually return to his normal activities (9). It advisable to stay below the cognitive and physical symptom-threshold-level, but the aim is to gradually return to the normal sport. Typically, this takes a week.

Prolonged symptoms – why and what to do?

Roughly, the "normal" recovery time for an athlete after an SRC is by two weeks for an adult and by four weeks for a child. The "prolonged recovery" reflects a longer than expected time period, but is not necessarily linked to the ongoing physiological injury (1, 9). In fact, there is a growing body of evidence showing that the prolonged recovery after a concussion correlates much better with pre-injury personal factors such as resilience, mood or behavioral issues, and post-traumatic stress reaction, rather than the time of amnesia or unconsciousness, or even with a minor finding in a CT such as a small contusion (1, 9). In many studies the strongest predictor of a slower recovery from an SRC has been the severity of the person's initial symptoms in the first day or a few days after the injury.

Headache is the most common symptom of a brain injury. For that, as for any specific symptom,

a symptomatic treatment is advised. Sedative or "brain injury specific" drugs are not recommended.

Some prolonged symptoms may be caused by autonomic nervous malfunction, and physical therapy might help to improve it. This is similar to dizziness caused by benign paroxysmal positional vertigo that may react well to therapeutic exercise. Physical therapy may also help patients with cervical spine or vestibular dysfunction. A collaborative approach including cognitive behavioral therapy is recommended to deal with any persistent mood or behavioral issues. In general, the few patients with prolonged symptoms should be managed in a multidisciplinary collaborative setting by healthcare providers with experience in SRC.

References

1. Aivovammat. Käypä hoito – suositus. Suomalaisen Lääkäriseuran Duodecimin, Suomen Anestesiologiyhdistyksen neuroanestesian jaoksen, Suomen Fysiatriyhdistyksen, Suomen Neurokirurgisen Yhdistyksen, Suomen Neurologisen Yhdistyksen, Suomen Neuropsykologinen Yhdistys ry:n ja Suomen Vakuutuslääkärien Yhdistyksen asettama työryhmä. Helsinki: Suomalainen Lääkäriseura Duodecim, 2017. Saatavilla Internetissä: www.käypähoito.fi

2. Lehman EJ, Hein MJ, Baron SL, Gersic CM. Neurodegenerative causes of death among retired national football league players. Neurology 2012; 79: 1970 – 1974

3. Raj R, Kaprio J , Korja M, Mikkonen ED, Jousilahti P, Siironen J. Risk of hospitalization with neurodegenerative disease after moderate- to-severe traumatic brain injury in the working-age population: A retrospective cohort study using the Finnish national health registries. PLoS Med 2017; 14(7): e1002316. https://doi.org/ 10.1371/journal.pmed.1002316

4. Godbolt AK, Cancelliere C, HIncapie CA, Marras C, Boyle E, Krostman VL et al. Systematic review of the risk of dementia and chronic cognitive impairement after mild traumatic brain injury: results of the international collaboration on mild traumatic brain injury prognosis. Archives of physical medicine and rehabilitation 2014; 95: 5245-5256

5. Iverson GI, Keene CD, Perry G, Castellani RJ. The need to separate chronic traumatic encephalopathy neuropathology from clinical features. Journal of Alzheimer's disease 2018; 61:17-28

6. Puljula J, Vaaramo K, Tetri S, Juvela S, Hillbom M. Risk for All-cause and Traumatic Death in Head Trauma Subjects: A Prospective Population-based Case-control Follow-up Study. Ann Surg. 2016; 263(6):1235-1239

7. Leddy JJ, Wilber CG, Wiler BS. Active recovery from concussion. Curr Opin Neurol 2018; 31:681-686

8. Chan C, Iverson GL, Purtzki J et al. Safety of active rehabilitation for persistent symptoms after pediatric sport-related concussion: a randomized, controlled trial. Arch Phys Med Rehabil 2018; 99:242-249

9. McCrory P, Meeuwisse W, Dvorak J, Aubry M, Bailes J, Broglio S et al. Consensus statement in sport-the 5th international conference on concussion in sport held in Berlin, October 2016. Br J Sports Med 2017; doi:10.1136/bjsports-2017-097699

Vertebral fractures - is there a valid concept for (osteoporosis) treatment recommendation today?

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Objectives

Vertebral fractures are said to be the most common of all fragility fractures. They account for an estimated 700,000 of the 1.5 million osteoporotic fractures occurring annually in the United States alone.

Despite the importance of this fracture type, no optimal method or appropriate cut-off point for defining a vertebral fracture has yet been found. Depending on the method and the cut-off point chosen to define a vertebral fracture, fracture prevalence can differ two- to four-fold differences.

According to some studies only around 30% of vertebral deformations deemed warranting a fracture label are symptomatic. Furthermore, numerous studies have shown that patient-important outcomes – namely, back pain, disability, health-related quality of life, psychosocial problems and prediction of subsequent fractures – only have a significant association with moderate to severe vertebral deformities. Mild deformities, which represent about 50% of all vertebral fractures, are not or only poorly associated with such outcomes.

Methods

For our analysis we reviewed all major osteoporosis guidelines in the world regarding the following two questions:

1. Did the guideline provide any definition for vertebral fractures, i.e., define the method to examine x-rays and the criteria to be used to deem a deformation in a spine x-ray/bone densitometry scan as a vertebral fracture?
2. Was vertebral fracture considered an indication for initiation of osteoporosis drug treatment?

Additionally, we also reviewed the original 21 trials underlying the NICE appraisal on "Bisphosphonates in Osteoporosis" regarding the following two questions:

1. What assessment method and criteria were used for defining prevalent (baseline) and incident (new) vertebral fractures (baseline)?
2. Were clinical vertebral fractures recorded, and if yes, how were they assessed?

Results

The absence of a gold standard defining a "deformation" as a fracture is readily apparent in the osteoporosis guidelines: 31/43 guidelines do not provide any recommendation on the preferred method or diagnostic criteria and of the 12 guidelines that do, there is considerable variation regarding the recommendations. Remarkably, 28 of the 31 guidelines that fail to provide any definition on how to make the diagnosis still recommend initiation of pharmacotherapy in patients with a vertebral fracture.

Also, in the pivotal trials underlying the NICE appraisal on "Bisphosphonates in Osteoporosis", there was no reliability or coherence to the way the pivotal pharmaceutical trials examined X-rays to decide whether or not patients had sustained a vertebral fracture. Furthermore, only 2 of the 21 trials used clinical vertebral fractures as their primary outcome.

Conclusion

Current definitions used by vertebral fracture scoring methods seem to be based on arbitrary cut-offs. If asymptomatic vertebral deformations are not truly clinically relevant, then using them as risk factors for future risk prediction may lead to over-estimation of risk and, therefore, also to overtreatment. As anti-vertebral fracture efficacy is the central basis for the approval of practically all current and forth-coming osteoporosis drugs, it is of particular importance to tease out the true validity of this most widely endorsed rationale for the use of osteoporosis medication. We propose an individual patient data meta-analysis which re-analyses existing data, with independent, blinded adjudication of all vertebral fractures and separation of asymptomatic and symptomatic vertebral fracture outcomes. This will verify whether or not the asserted anti-vertebral fracture efficacy is valid.

Säären avaava osteotomia polven mediaalisen nivelrikon hoidossa

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HYKS, Töölön sairaala

Medial high tibial opening wedge osteotomy (HTO) is the treatment of choice for medial osteoarthritis (OA) of the knee in relatively young and active population. Previously the grade of OA at medial tibio-femoral joint has been proposed to affect the clinical outcome. The aim of this retrospective study was to evaluate whether the level of OA in the knee, and in its three different compartments diagnosed with radiography and arthroscopy, alter the clinical outcome of HTO and the long-term survival. We conducted a retrospective study of all HTO patients with primary medial osteoarthritis to evaluate the clinical outcome and long-term survival. We identified a total of 151 HTO procedures made due to symptomatic primary medial OA of the with minimum of 1-year follow-up. The chondral injuries for each three knee joint compartments were graded during arthroscopy (modified Outerbridge) and from plain standing radiographs (Kellgren-Lawrence). Altogether 12 knees were revised to TKA. Mean time to failure was 4.2 years (range 1.5-11.8 years). Kaplan-Meier survival of HTO was 90.6% (95% CI, 84.0%-97%) at 5 years and 84.7% (95% CI, 75%-94%) at 10 years. Severe OA grade 3 or 4 (arthroscopic and radiographic) medial of the knee was detected in 143 (94.7%) patients at arthroscopy and in 76 (50.3%) patients in plain x-ray images. The degree of OA in any of the three knee compartments did not affect the survival rates. The survival was good also in the severe medial OA group (K-L 3 to 4). HTO was beneficial at the present study population with a good 5-year survival and with good subjective outcomes.

Johdanto

Säären korkean avaavan osteotomian (HTO) on katsottu soveltuvan mediaalisen artroosin hoidoksi nuorilla ja aktiivisilla potilailla joilla on raajan varus -suuntainen akselivirhe (1). Polven nivelrikko aiheuttaa painon epätasaisen jakautumisen kantavilla nivelpinnoilla (2,3). HTO -toimenpiteellä voidaan muuttaa tätä nivelrikon aiheuttamaa ja rakenteellista varisoitunutta mekaanista akselia ja siten hidastaa nivelrikon etenemistä (3).

HTO toimenpiteen jälkeen osalle kuitenkin joudutaan tekemään polven totaaliprotetisaatio (TKA) kipuoireiston uusiutuessa. Polven protetisaatioon johtaneiden tapausten osuus vaihtelee suuresti kirjallisuudessa (4).

Parhaimmat hyödyt HTO -toimenpiteelle on katsottu saavutettavan nuorilla potilailla, joilla on isoloitunut mediaalinen polvinivelen nivelrikko (5). Kuitenkin selkeätä näyttöä HTO -toimenpiteen tehosta ei ole osoitettu ja näyttö pitkäaikaisista tuloksista on niukkaa (5,6). Niemeyer et al. totesivat, että nivelruston vaurioaste polven mediaalisesti kantavassa nivelpinnassa on merkityksetöntä eikä vaikuta kliiniseen lopputulokseen (7), eikä myöskään osittaiset rustovauriot lateraalisella

nivelpinnalla vaikuttaneet lopputuloksiin (8).

Tutkimuksemme tarkoituksena oli selvittää vaikuttaako polvinivelen radiologinen tai artroskooppinen nivelrikon aste HTO-toimenpiteen lopputulokseen tai TKA:n tarpeeseen. Hypoteesina oli, että HTO soveltuu myös vaikeampiasteisen polven mediaalisen nivelrikon (Kellgren-Lawrence luokat III-IV) hoitoon. Tämän selvittämiseksi tutkimme retrospektiivisesti kaikki Töölön sairaalan ja Peijaksen sairaalan potilaat, joille on tehty HTO mediaalisen polven nivelrikon vuoksi kymmenen vuoden ajalta.

Metodit

Potilastietojärjestelmistä identifioitiin yhteensä 151 HTO-toimenpidettä HYKS sairaaloista vuosien 2006-2016 aikana, jotka oli tehty polven mediaalisen nivelrikon hoitoon. Leikkaavia ortopedeja oli yhteensä 23. Osteotomialeikkauksen yhteydessä suoritettiin ensin polven artroskopia, jossa selvitettiin rustovaurioiden vaurioaste (modifioitua Outerbridge) kaikissa kolmessa kompartmentissa. HTO tehtiin käyttäen TomoFix Medial High Tibial -levyä (DePuy Synthes, Raynham, Massachusetts, United States). Lisäksi kaksi radiologia arvioi preoperatiivisista seisten otetuista polven kuormitusröntgenkuvista radiologisen nivelrikon asteen sokkoutetusti. Jokainen nivelpinta (mediaalinen tibio-femoraalinen, lateraalinen tibio-femoraalinen ja patello-femoraalinen) gradeerattiin käyttäen Kellgren-Lawrencen (K-L) -luokitusta.

Potilaille lähetettiin oirekyselykaavake sisältäen KOOS-pisteytyksen. Kaplan-Meier -analyysissä asetettiin TKA kuvaamaan HTO -hoidon epäonnistumiseksi.

Tulokset

Potilaiden keskimääräinen seuranta-aika oli 4,7 (1,2-11,8) vuotta. Potilaista 104 (69%) oli miehiä. Potilaiden mediaani-ikä oli 48,2 -vuotta (21,4-67,4) ja BMI oli 28,3 (20,4-38,0). TKA tehtiin 12 potilaalle (8%) keskimäärin 4,2 vuoden (1,5-11,8) kohdalla HTO-toimenpiteestä. Tämän aineiston osalta HTO-toimenpiteen arvioitu selviämisennuste oli 10,8 vuotta (95% CI, 10,1-11,4 vuotta). Kaplan-Meier -analyysin perusteella kumulatiivinen selviytymisosuus on 5 vuoden kohdalla 90,6% (95% CI, 84.0%-97%) ja 10 vuoden kohdalla 84,7% (95% CI, 75%-94%) (Kuva 1).

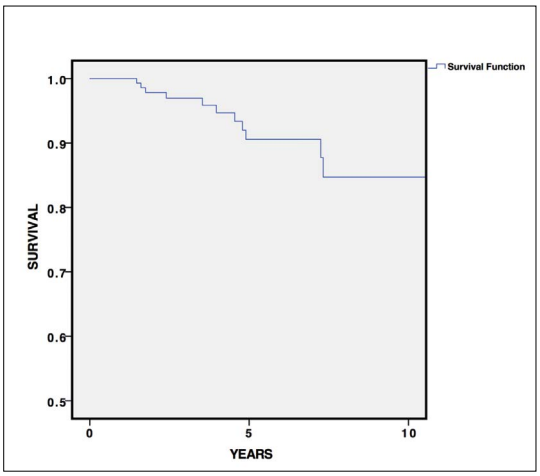
Kaplan-Meier -analyysissä polvinivelen eri nivelrikon asteilla saatiin eri ennustearvoja 5-vuoden kohdalla, mutta näitä arvoja ei voi pitää tilastollisesti merkitsevinä (Taulukko 1). Riskianalyysissä radiologinen tai artroskooppinen nivelrikon aste ei vaikuttanut riskiin joutua proteesileikkaukseen (Taulukko 2).

Artroskooppisen ja radiologisen luokittelun välillä oli selkeitä eroja (Kuva 2). Korkeita polven nivelrikon asteita (gradus 3 tai 4) todettiin artroskopiassa 143 (94.7%) potilaalla ja röntgenkuvissa 76 (50.3%) potilaalla. Mediaalisella nivelpinnalla nähtiin artroskooppisesti merkitsevästi korkeampia vaurioita kuin radiologisesti (3,58 vs. 2,41, p<0,001). Toisaalta radiologinen arvio antoi lateraalisella nivelpinnalla suurempia vaurioasteita verrattuna artroskopia löydökseen (Taulukko 3).

Kyselyiden vastausprosentti oli 72.2%. Vastaamatta jättäneet potilaat pyrittiin kontaktoimaan vielä puhelimitse ja näin saavutettiin 89% vastausprosentti. 105 (96.3%) katsoi hyötyneensä toimenpiteestä. Potilaista 80 (73.4%) valitsisi HTO-toimenpiteen vastaaviin oireisiin toiseen polveensa. KOOS -pisteytyksen perusteella potilailla meni kohtalaisen hyvin (Kuva 3).

Lopuksi

Suurin osa HTO-toimenpiteistä oli tehty luokkien 3 ja 4 mediaalisen kantavan nivelpinnan hoidoksi eivätkä nämä korkeammat nivelrikon asteet ennustaneet TKA-toimenpiteeseen päätymistä. Tapauksis-



Kuva1. Survival of HTO to TKA using Kaplan-Meier analysis.

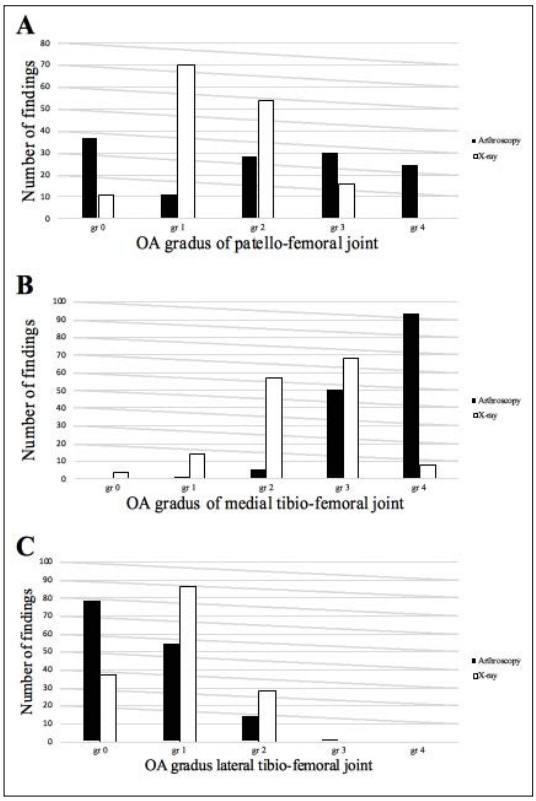
Taulukko 1. Kaplan-Meier 5-year survival rates with different OA grades - radiographic (Kellgren-Lawrence score) and arthroscopy (Modified Outerbridge score).

Knee joint	***Classification***	***0***	***1***	***2***	***3***	***4***
Medial	***Radiographic***	100%	100%	82.1%	93.6%	87.5%
	Arthroscopy	-	-	100%	92.8%	83.9%
Lateral	***Radiographic***	87%	89.8%	96.2%	-	-
	Arthroscopy	92.3%	85.8%	91.7%	-	-
Patello-femoral	***Radiographic***	100%	90.3%	90.5%	85.6%	-
	Arthroscopy	78.4%	100%	100%	91.0%	86.7%

Taulukko 2. Different factors evaluated for treatment failure (conversion to TKA).

Factor	Hazard ratio (C.I. 95%)	p-value
Age	1.051 (0.978-1.130)	0.178
Gender	1.499 (0.403-5.578)	0.546
Weight	1.024 (0.988-1.061)	0.194
BMI	1.098 (0.963-1.254)	0.164
Radiographic OA		
MTF	1.059 (0.564-1.988)	0.858
LTF	1.073 (0.457-2.519)	0.872
PF	1.726 (0.838-3.557)	0.139
Arthroscopic cartilage damage		
MTF	1.745 (0.522-5.832)	0.366
LTF	1.196 (0.584-2.450)	0.625
PF	0.873 (0.578-1.319	0.519

Kuva 2. Level of OA at different compartments according to radiographic and arthroscopy findings



Taulukko 3. Comparison between preoperative radiographic and perioperative arthroscopy grade of osteoarthrosis.

Compartment	***Preoperative K-L***	***Perioperative Outer-bridge***	***Spearman correlation non-parametric***	***P-value***
M-TF	2.41 (0-4)	3.58 (1-4)	0.340	<0.001
PF	1.50 (0-3)	1.90 (0-4)	0.290	0.001
L-TF	0.94 (0-2)	0.58 (0-3)	0.150	0.069

K-L: Kellgren-Lawrence classification.
M-TF: medial tibio-femoral joint; PF: Patello-femoral joint; L-TF: lateral tibio-femoral joint.

Kuva 3. The KOOS scores of study populatio and comparable KOOS scores from other studies (9-11).

sa, joissa lieväasteinen radiologinen tai artroskooppinen nivelrikko todettiin myös lateraalisessa ja/tai patellofemoraalisessa nivelessä eivät korostuneet potilailla, joille tehtiin TKA. Tutkimuksessa kerätty subjektiivinen arvio polvesta (KOOS-pisteytys) on linjassa muun kirjallisuuden kanssa HTO-toimenpiteen tehossa hoitaa nivelrikon aiheuttamia oireita, kipua sekä parantamaan päivittäistä toimintakykyä (ADL toiminta). Tutkimuksen perusteella HTO vaikuttaa olevan hyödyllinen toimenpide polven mediaalisen nivelrikon hoidossa myös pidemmälle edenneessä taudissa.

Viitteet

1. Richmond J, Hunter D, Irrgang J, Jones MH, Levy B, Marx R, et al. Treatment of osteoarthritis of the knee (nonarthroplasty). Vol. 17, The Journal of the American Academy of Orthopaedic Surgeons. NIH Public Access; 2009. pp. 591–600.

2. Sharma L, Chmiel JS, Almagor O, Felson D, Guermazi A, Roemer F, et al. The role of varus and valgus alignment in the initial development of knee cartilage damage by MRI: the MOST study. Ann Rheum Dis. BMJ Publishing Group Ltd; 2013 Feb;72(2):235–40.

3. Felson DT. Osteoarthritis as a disease of mechanics. Osteoarthr Cartil. 2013 Jan;21(1):10–5.

4. Dettoni F, Bonasia DE, Castoldi F, Bruzzone M, Blonna D, Rossi R. High tibial osteotomy versus unicompartmental knee arthroplasty for medial compartment arthrosis of the knee: a review of the literature. Iowa Orthop J. University of Iowa; 2010;30:131–40.

5. Amendola A, Bonasia DE. Results of high tibial osteotomy: review of the literature. Int Orthop. Springer-Verlag; 2010 Feb;34(2):155–60.

6. Brouwer RW, Huizinga MR, Duivenvoorden T, van Raaij TM, Verhagen AP, Bierma-Zeinstra SMA, et al. Osteotomy for treating knee osteoarthritis. Cochrane Musculoskeletal Group, editor. Cochrane Database Syst Rev. 2014 Dec 13;10(12):CD004019.

7. Niemeyer P, Schmal H, Hauschild O, Heyden von J, Südkamp NP, Köstler W. Open-wedge osteotomy using an internal plate fixator in patients with medial-compartment gonarthritis and varus malalignment: 3-year results with regard to preoperative arthroscopic and radiographic findings. Arthroscopy. 2010 Dec;26(12):1607–16.

8. Niemeyer P, Schmal H, Hauschild O, Heyden von J, Südkamp NP, Köstler W. Open-wedge osteotomy using an internal plate fixator in patients with medial-compartment gonarthritis and varus malalignment: 3-year results with regard to preoperative arthroscopic and radiographic findings. Arthroscopy. 2010 Dec;26(12):1607–16.

9. Nilsdotter A-K, Toksvig-Larsen S, Roos EM. A 5 year prospective study of patient-relevant outcomes after total knee replacement. Osteoarthr Cartil. 2009 May;17(5):601–6.

10. Marot V, Murgier J, Carrozzo A, Reina N, Monaco E, Chiron P, et al. Determination of normal KOOS and WOMAC values in a healthy population. Knee Surg Sports Traumatol Arthrosc. Springer Berlin Heidelberg; 2018 Sep 24;38:1334–8.

11. Lind-Hansen TB, Lind MC, Nielsen PT, Laursen MB. Open-Wedge High Tibial Osteotomy: RCT 2 Years RSA Follow-Up. J Knee Surg. Thieme Medical Publishers; 2016 Nov;29(8):664–72.

Akuutin akillesrepeämän hoito

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Acute rupture of the Achilles tendon is one of the most common sport injuries involving mostly middle aged men. The diagnosis is clinical. MRI is reserved for cases with incongruous clinical findings. The results of conservative treatment with early weight-bearing and accelerated ankle rehabilitation with adjustable ankle orthosis are comparable to results of surgical repair in terms of re-rupture rate, clinical outcomes and the patient's ability to return to their previous physical activities. Conservative treatment is preferred for most patients because it has a significantly lower rate of complications compared to surgical repair. There is lack of evidence for any benefits of weight-bearing restrictions in both conservative and post-operative treatment. Early or even immediate weight-bearing in both treatment groups is associated with more rapid recovery, better clinical results and lower complication rates.

Akillesjänteen akuutti repeämä on yleisimpiä liikuntavammoja, ja sen esiintyvyys on ollut nousussa viime vuosikymmeninä (1,2). Potilaat ovat voittopuolisesti (3:1) miehiä ja keski-ikäisiä (1). Vammamekanismi on usein tavallinen ponnistustilanne tai jännevamoille tyypillisesti jännittyneeseen jänteeseen tuleva yllättävä voima.

Akillesjännerupturan diagnoosi on kliininen (3,4). Diagnoosiin riittää kaksi seuraavista: positiivinen Thompson, positiivinen Matles, palpoituva kuoppa tai alentunut nilkan plantaarifleksiovoima (5). Thompsonin ja Matlesin testit ovat näistä sensitiivisimmät (6). Epäselvissä tapauksissa apuna voi käyttää kuvantamista erikoislääkärin harkinnan mukaan. Ensilinjan modaliteetti on magneettitutkimus. Kuvantamisen viitteellisinä kriteereinä voidaan pitää epäjohdonmukaisia kliinisiä löydöksiä sekä niitä tilanteita kun taustalla on aikaisempaa akillespatologiaa tai vammasta on kulunut yli 4vko. Ultraääni on tutkimusoloissa todettu osuvuudeltaan hyväksi, mutta siihen sisältyy huomattavaa tekijäkohtaista laadun vaihtelua, eikä sitä siksi voi pitää yleisesti kaikkiin terveydenhuollon yksiköihin suositeltavana.

Akillesrepeämän hoitolinjan valinnasta konservatiivisen ja kirurgisen hoidon välillä on ollut historian aikana erilaisia painotuksia. Akuutin repeämän leikkaushoidon määrät ovat viimeisen vuosikymmenen aikana olleet laskussa Suomessa. Syynä tähän ovat todennäköisesti olleet tuoreet aiheesta julkaistut korkeatasoiset tutkimukset, jotka ovat puoltaneet ensisijaisesti leikkauksetonta hoitoa (7).

Valinnassa konservatiivisen ja operatiivisen hoidon välillä on kyse tasapainoilusta riskien ja saavutettavan hyödyn välillä. Tuoreiden hyvälaatuisten systemaattisten katsausten ja meta-analyysien pohjalta tiedetään, että operatiivisen ja konservatiivisen hoidon tulokset ovat potilaan kokemana yhtäläiset. Komplikaatioita on kuitenkin enemmän kirurgisesti hoidettujen joukossa (8-10). Viimeisimmässä tänä vuonna ilmestyneessä meta-analyysissä, joka käsitti 10 kaksoissokkoutettua tutkimusta (944pt) ja 19 havainnoivaa tutkimusta (14918pt), komplikaatioita oli konservatiivisesti hoidetuilla 1,6%:lla ja leikatuilla 4,9%:lla (sis. infektiot 2,8%). Vastaavasti uusintarepeämiä oli koko aineistossa konservatiivisessa hoidossa 3,9%:lla ja leikatuilla 2,3%:lla. Merkittävää oli, että kun tarkasteltiin tutkimuksia, joissa konservatiivinen hoito oli toteutettu varhaisella pai-

nonvarauksella ja mobilisaatiolla, eroja ei hoitotapojen välillä ollut.

Toiminnallisessa tuloksessa on todettu parempia tuloksia leikkaushoidetuilla funktionaalisissa testeissä (hypyt, varpaillenousu jne), mutta ei eroa ryhmien välillä nilkan liikelaajuksissa, paluussa samalle tasolle liikuntaan eikä elämänlaatumittareissa (PROMit) (8,10).

Konservatiivisen hoidon ja leikkauksenjälkeisen kuntoutuksen osalta on 2010-luvulla saatu uutta näyttöä varhaisemman painonvarauksen ja aikaisemmin sallitun ortoosilla suojatun nilkan liikkeen tuomista eduista (8-10). Kuntoutuksen protokollia on julkaistu useita ja kaikissa merkittävimmissä tutkimuksissa on ollut käytössä toisistaan poikkeavat protokollat, mikä vaikeuttaa niiden vertailua.

Konservatiivisen hoidon osalta on vahva näyttö, että varhainen (<4vko) varaus yhdistettynä aikaiseen mobilisaatioon ortoosisuojassa tuottaa kirurgiseen hoitoon verrattavan potilastyytyväisyyden ja vähentää uusintarepeämäriskiä (11-14). Useissa töissä varaus on sallittu välittömästi ja lienee todennäköistä, että tästä ei ole haittaa vaikka laadukkaita vertailevia töitä aiheesta ei olekaan julkaistu (13-15).

Leikkauksessa akillesjänne voidaan korjata täysin avoimesti tai eriasteisen perkutaanisesti. Kudosaugmenttien käytöstä rutiinisti primäärileikkauksissa ei ole osoitettu hyötyä. Avoimeen suturaatioon on kuvattu useita eri leikkaustekniikoita, mutta mitään yksittäistä ei ole todettu merkittävästi toista paremmaksi kadaveri- tai potilasaineistoissa (16,17). Perkutaaniseen tekniikkaan vaikuttaisi liittyvän lyhyempi leikkausaika, vähemmän infektioita ja paremmat AOFAS-pisteet kuin avoimeen korjaukseen mutta toisaalta korkeampi riski nervus suralis -vaurioihin. Uusintarepeämien suhteen kumpikin tekniikka vaikuttaa olevan tasaveroinen (18).

Leikkauksenjälkeisessä kuntoutuksessa on osoitettu yhdistetyn varhaisen painonvarauksen ja varhaisen mobilisaation johtavan parempaan kliiniseen lopputulokseen ja nopeampaan toipumiseen vähemmin komplikaatioin (19-21). Täysipainovarauksen ja nilkan liikkeen tiedetään ehkäisevän syvien laskimotukosten syntymistä. Täysipainovarauksesta jopa välittömästi operatiivisen hoidon jälkeen on saatu hyviä toiminnallisia tuloksia (13,22).

Yhteenvetona voidaan todeta, että paras hoitotulos akillesrupturapotilaalle voidaan taata kun akillesrepeämän diagnoosiin päästään viiveettä, hoitolinja valitaan oikein yhdessä potilaan kanssa ja kuntoutuksessa käytetään fysioterapeutin ohjauksessa varhaista painonvarauksta ja ortoosilla suojattua varhaista mobilisaatiota.

Viitteet

1. Ganestam A, Kallemose T, Troelsen A & Barfod KW. Increasing incidence of acute Achilles tendon rupture and a noticeable decline in surgical treatment from 1994 to 2013. A nationwide registry

2. study of 33 160 patients. Knee Surg Sports Traumatol Arthrosc. 2016;24:3730-3737.

3. Lantto I. Acute Achilles tendon rupture : epidemiology and treatment – Academic Dissertation. Acta Univ. Oul. D 1359, 2016 http://jultika.oulu.fi/files/isbn9789526211985.pdf

4. Garras DN, Raikin SM, Bhat SB, Taweel N, Karanjia H. MRI is unnecessary for diagnosing acute Achilles tendon ruptures: clinical diagnostic criteria. Clin Orthop Relat Res. 2012;470: 2268–2273.

5. Gross CE, Nunley JA II. Acute Achilles Tendon Ruptures. Foot Ankle Int. 2016;37:233-239.

6. The American Academy of Orthopaedic Surgeons, Clinical Practice Guidelines 2019

7. http://www.orthoguidelines.org/topic?id=1000

8. Maffulli N. The clinical diagnosis of subcutaneous tear of the Achilles tendon. A prospective study in 174 patients. Am J Sports Med. 1998;26:266-70.

9. Mattila VM, Huttunen TT, Haapasalo H, Sillanpaa P, Malmivaara A & Pihlajamaki H (2015) Declining incidence of surgery for Achilles tendon rupture follows publication of major RCTs: evidenceinfluenced change evident using the Finnish registry study. Br J Sports Med. 2015;49:1084–1086.

10. Deng S, Sun Z, Zhang C, Chen G, Li J. Surgical Treatment Versus Conservative Management for Acute Achilles Tendon Rupture: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. J Foot Ankle Surg. 2017;56:1236-1243.

11. Ochen Y (2019); Operative treatment versus nonoperative treatment of Achilles tendon ruptures: systematic review and meta-analysis, BMJ. 2019 Jan 7;364:k5120

12. Ke Z (2018), Surgical Versus Non-Surgical Methods for Acute Achilles Tendon Rupture:A Meta-Analysis of Randomized Controlled Trials; The Journal of Foot & Ankle Surgery 57(2018)1191-1199

13. Barfod KW, Bencke J, Lauridsen HB, Ban I, Ebskov L, Troelsen A. Nonoperative dynamic treatment of acute Achilles tendon rupture: the influence of early weight-bearing on clinical outcome: a blinded, randomized controlled

trial. J Bone Joint Surg Am. 2014;96:1497-1503.

14. Willits K, Amendola A, Bryant D et al. Operative versus nonoperative treatment of acute Achilles tendon ruptures: a multicenter randomized trial using accelerated functional rehabilitation. J Bone Joint Surg Am.2010;92:2767–2775.

15. Costa ML, MacMillan K, Halliday D et al. Randomised controlled trials of immediate weight-bearing mobilisation for rupture of the tendo Achillis. J Bone Joint Surg Br. 2006;88:66–77.

16. Olsson N, Silbernagel KG, Eriksson BI, Sansone M, Brorsson A, Nilsson-Helander K, Karlsson J. Stable surgical repair with accelerated rehabilitation versus nonsurgical treatment for acute

17. Achilles tendon ruptures: a randomized controlled study. Am J Sports Med. 2013;41:2867–2876.

18. Metz R, Verleisdonk EJ, van der Heijden GJ et al. Acute Achilles tendon rupture: minimally invasive surgery versus nonoperative treatment with immediate full weight-bearingda randomized controlled trial. Am J Sports Med. 2008;36:1688–1694.

19. McCoy BW, Haddad SL. The strength of achilles tendon repair: a comparison of three suture techniques in human cadaver tendons. Foot Ankle Int. 2010;31:701-705.

20. Sadoghi P, Rosso C, Valderrabano V, Leithner A, Vavken P. Initial Achilles tendon repair strength—synthesized biomechanical data from 196 cadaver repairs. Int Orthop. 2012;36: 1947–1951.

21. Yang B, Liu Y, Kan S, Zhang D, Xu H, Liu F, Ning G, Feng S. Outcomes and complications of percutaneous versus open repair of acute Achilles tendon rupture: International Journal of Surgery Volume 40, April 2017, Pages 178-186.

22. Maffulli N, Tallon C, Wong J, Lim K, Bleakney R. Early weightbearing and ankle mobilization after open repair of acute midsubstance tears of the Achilles tendon. Am J Sports Med. 2003;31:692–700.

23. Suchak AA, Bostick GP, Beaupre LA, Durand DC, Jomha NM. The influence of early weight-bearing compared with non-weight-bearing after surgical repair of the Achilles tendon. J Bone Joint Surg Am. 2008;90:1876–1883.

24. Huang J, Wang C, Ma X, Wang X, Zhang C, Chen L. Rehabilitation regimen after surgical treatment of acute Achilles tendon ruptures: a systematic review with meta-analysis.Am J Sports Med. 2015 Apr;43(4):1008-16

25. Kearney RS, Costa ML. Current concepts in the rehabilitation of an acute rupture of the tendo Achillis. J Bone Joint Surg Br .2012;94(1):28-31

Verityhjiön käyttö polven tekonivelkirurgiassa - Tourniquet use in total knee arthroplasty

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Total knee arthroplasty is a highly effective treatment for end-stage knee osteoarthritis and it can be performed with or without a surgical tourniquet. Tourniquets are commonly used in total knee arthroplasty to provide better visualisation and facilitate cementing techniques. Several studies have reported similar outcomes with both techniques regarding postoperative blood loss measured using drains, blood transfusion rates, operative time, component positioning, cement fixation, LOS, and knee function after three months. Nevertheless, there is evidence on the negative effects of a tourniquet use on the patient's recovery following total knee arthroplasty. Soft tissue damage, swelling, skin problems, nerve palsy, weakening the thigh muscles and increase in postoperative pain thus hindering mobilization and increasing LOS, deep vein thrombosis and increasing 30-day readmission has been described. Positive effects of a tourniquet use remains minor. Modern fast-track total-knee-arthroplasty protocols are trying to reduce length of stay and expedite the ambulation and general rehabilitation without increasing complications, thus the use of tourniquet should be critically evaluated when performing total knee arthroplasty.

Johdanto

Polven tekonivelleikkaus on vaikuttavaa pitkälle edenneen polven nivelrikon hoitoa. Polven tekonivelleikkaus voidaan tehdä joko verityhjiön kanssa tai ilman. Verityhjiön käyttö on varsin yleistä, ja sen käytön perusteina on pidetty leikkausalueen hyvää näkyvyyttä, nopeampaa leikkausaikaa sekä vähäisempää verenvuotoa leikkauksen aikana [1]. Polven tekonivelkirurgiassa näkyvyyden lisäksi tärkeimpänä etuna on pidetty sitä, että verityhjiön aikana toteutetun komponenttien sementtikiinnitys on parempi. Verityhjiön käytön komplikaatioina on raportoitu pehmytkudosvauriota, alaraajaturvotusta, iho- ja hermovaurioita, lihasvoiman heikentymistä ja lisääntynyttä välitöntä leikkauksen jälkeistä kipua sekä syviä laskimotukoksia. Selkeitä hyötyjä verityhjiön käytöstä ei ole tutkimuksissa kuitenkaan pystytty osoittamaan [2].

Historia

Verityhjiö tai kiristysside on kuvattu jo roomalaisen kirurgin käyttämänä toisella vuosisadalla. Lisääntyvässä määrin kiristyssidettä käytettiin keskiajalla sodissa verenvuodon estoon raajojen vammojen sekä amputaatioiden yhteydessä. Nykyään käytössä oleva tourniquet-nimityksen keksi ranskalainen kirurgi Jean Louis Petit (1674-1750), joka kehitti ruuvilla kiristettävän laitteen. Ensimmäisen varsinaisen kirurgisen verityhjiön tai kiristyssiteen amputaation yhteydessä kuvasi Eschmarkin vuonna 1873. Pneu-

maattisen verityhjiömansetin otti käyttöön Harvey Cushing vuonna 1904 [3,4].

Verityhjiön käyttö

Turvallisin tapa poistaa veri alaraajasta on alaraajan nostaminen kohoasentoon 45 asteen kulmaan viiden minuutin ajaksi ennen tyhjiömansetin täyttöä, jolloin voidaan välttää mahdollisia iho-ongelmia sekä välitöntä leikkauksen jälkeistä kipua [5]. Verityhjiömansetti tulee asettaa reiteen oikealle korkeudelle, mansetin tulee olla sopivan kokoinen sekä mansetin paine tulee asettaa mahdollisimman alhaiseksi, jotta vältetään mansetin aiheuttama painevauriot pehmytkudoksiin. Tavallinen alaraajamansettiin asetettava paine on 250mmHg, yleensä 75-100mmHg yli systolisen paineen riittää [6]. Verityhjiön käyttöaika leikkauksessa on rajallinen. Suhteellisen turvallisena verityhjiöaikana on pidetty 120 minuuttia [7]. Tätä pidemmissä leikkauksissa on verityhjiö väliaikaisesti vapautettava vähintään 10-15 minuutin ajaksi tai poistettava kokonaan iskemian aiheuttamien vaurioiden estämiseksi [8]. Tavoitteena tulisi aina kuitenkin olla mahdollisimman lyhyt verityhjiöaika. Verityhjiön käytön vasta-aiheina pidetään vaikeaa valtimoiden kovettumatautia, diabetestä, vaikeaa ruhje- ja aivovammaa sekä sirppisoluanemiaa. Relatiivisina vasta-aiheina pidetään epäiltyä tai todettua syvää laskimotukosta, paikallisesti kalkkeutuneita verisuonia, nivelreumaa, vaskuliittia tai paikallista kasvainta [8].

Verityhjiön vaikutus polven tekonivelen sementtikiinnitykseen ja komponenttien asemointiin

Sementin tunkeutuminen luuhun ja sementtikiinnityksen lujuus komponentti-sementti ja sementti-luurajalla polventekonivelleikkauksen yhteydessä ovat yhdet tärkeimmistä polven tekonivelen pitkäaikaisennusteeseen vaikuttavista tekijöistä, sillä aseptinen irtoaminen on yksi suurimmista tekonivelen uusintaleikkausten syistä [9-11]. Verityhjiön käyttöä ja sementtikiinnitystä on tutkittu useammassa tutkimuksessa ja näissä ei ole todettu eroa sementtikiinnityksen laadussa [12-14]. Edellä mainituissa tutkimuksissa sementtikiinnityksen laatua ja pysyvyyttä on arvioitu radiostereometrisellä analyysillä (RSA), jota pidetään hyvänä implantin pitkäaikaispysyvyyden ennustajana [15-17]. Polven tekoniveliä koskeva rekisteritieto verityhjiön käytön vaikutuksista komponenttien pysyvyyteen puuttuu toistaiseksi. Stetzelbergerin tekemässä randoimoidussa työssä verityhjiön käytöllä ei näyttäisi olevan vaikutusta myöskään komponenttien tarkempaan asemointiin [18].

Verityhjiön vaikutus verenvuotoon, leikkausaikaan ja komplikaatioiden esiintyvyyteen

Useat tutkimukset ovat raportoineet verityhjiön vähentäneen leikkausaikaa ja verenvuotoa, mutta samaan aikaan verityhjiön käyttö mahdollisesti lisää leikkauksenjälkeistä kipua hidastaen potilaan mobilisoitumista ja pidentäen sairaalassaoloaikaa [12, 19, 20]. Alcelikin [2] 2012 julkaisemassa verityhjiön käyttöä koskevassa meta-analyysissa kokonaisvuoto hieman väheni (ka 184 ml), mutta leikkausajoissa ei todettu merkittävää eroa. Vähäisiä komplikaatioita sekä syviä laskimotukoksia näytti olevan hieman enemmän verityhjiöryhmässä. Smithin [21] 2010 julkaisemassa meta-analyysissä ei todettu eroa kokonaisverenvuodossa tai verensiirroissa ryhmien välillä, mutta verityhjiöryhmässä todettiin myös enemmän komplikaatioita. Eräässä retrospektiivisessä tutkimuksessa todettiin odottamaton kokonaisverenvuodon nousu potilailla, joilla käytettiin verityhjiötä [22]. Ricciardin [23] tutkimuksessa havaittiin käytetyn verityhjiöajan korreloivan suoraan lisääntyneeseen 30 vuorokauden readmissio-riskiin. Yleisesti tutkimuksista voidaan todeta, että verenvuoto vähenee verityhjiötä käytettäessä lähinnä vain leikkauksenaikaisen verenvuodon verran.

Verityhjiön käytön komplikaatioita on raportoitu runsaasti. Komplikaatioiden esiintyvyys on suhteellisen harvinaista. Komplikaatioina on kuvattu pehmyt- ja lihaskudosvaurioita, alaraajaturvotusta, lihasvoiman heikentymistä, hermovauriota, kalkkeutuneiden verisuonien vaurioita, alentunutta polven liikelaajuutta sekä laskimo- ja keuhkovaltimotukosten kehittymistä [12, 24-26].

Pohdinta

Verityhjiön käyttöä polven tekonivelkirurgian yhteydessä on tutkittu laajasti. Valtaosa tehdyistä tutkimuksista on ollut kuitenkin retrospektiiviä tutkimuksia. Yksittäisten prospektiivisten tutkimusten tutkimusasetelmissa sokkouttaminen ja etukäteiset voimalaskennat ovat usein puuttuneet ja lisäksi poti-

lasmäärät ovat yleensä olleet suhteellisen pieniä heikentäen tulostenvoimaa ja luotettavuutta.

Useat tutkimustulokset ovat raportoineet yhteneväisiä tuloksia suhteessa leikkauksen jälkeiseen vuotoon, verensiirtomääriin, komponenttiasemointiin, sementtikiinnitykseen, sairaalassaoloaikaan sekä polven toiminnalliseen tulokseen kolmen kuukauden kohdalla [12, 18, 21]. Verityhjiön käytön haittoja on kuvattu runsaasti, vaikkakin ne ovatkin suhteellisen harvinaisia.

Nykyisten tutkimustulosten valossa verityhjiön käytön hyödyt näyttävät jäävän vaatimattomiksi. Näin ollen verityhjiön käytöstä saavutettavia vähäisiä hyötyjä tulee punnita kriittisesti suhteessa tyhjiön käytön aiheuttamiin mahdollisiin haittoihin.

References

1. Tai, T.W., et al., Tourniquet use in total knee arthroplasty: a meta-analysis. Knee Surg Sports Traumatol Arthrosc, 2011. 19(7): p. 1121-30.

2. Alcelik, I., et al., A comparison of outcomes with and without a tourniquet in total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. J Arthroplasty, 2012. 27(3): p. 331-40.

3. Welling, D.R., et al., A brief history of the tourniquet. J Vasc Surg, 2012. 55(1): p. 286-90.

4. Hawk, A.J., ArtiFacts: Jean Louis Petit's Screw Tourniquet. Clin Orthop Relat Res, 2016. 474(12): p. 2577-2579.

5. Zhang, M., et al., Comparison of lower limb lifting and squeeze exsanguination before tourniquet inflation during total knee arthroplasty. BMC Musculoskelet Disord, 2019. 20(1): p. 35.

6. Tuncali, B., et al., A new method for estimating arterial occlusion pressure in optimizing pneumatic tourniquet inflation pressure. Anesth Analg, 2006. 102(6): p. 1752-7.

7. Wakai, A., et al., Pneumatic tourniquets in extremity surgery. J Am Acad Orthop Surg, 2001. 9(5): p. 345-51.

8. Estebe, J.P., J.M. Davies, and P. Richebe, The pneumatic tourniquet: mechanical, ischaemia-reperfusion and systemic effects. Eur J Anaesthesiol, 2011. 28(6): p. 404-11.

9. Nagel, K., et al., The Influence of Cement Morphology Parameters on the Strength of the Cement-Bone Interface in Tibial Tray Fixation. J Arthroplasty, 2017. 32(2): p. 563-569.e1.

10. Hip and Knee Replacements in Canada, 2016–2017: Canadian Joint Replacement Registry (CJRR) Annual Report Canadian Institute for Health Information. Ottawa, ON., Canada, 2018. https://secure.cihi.ca/free_products/cjrr-annual-report-2018-en.pdf.

11. National Joint Registry: 14th Annual Report. National Joint Registry for England, Wales, Northern Ireland and the Isle of Man. 2017. http://www.njrreports.org.uk/Portals/0/PDFdownloads/NJR%2014th%20Annual%

12. Ejaz, A., et al., Absence of a Tourniquet Does Not Affect Fixation of Cemented TKA: A Randomized RSA Study of 70 Patients. J Arthroplasty, 2015. 30(12): p. 2128-32.

13. Molt, M., A. Harsten, and S. Toksvig-Larsen, The effect of tourniquet use on fixation quality in cemented total knee arthroplasty a prospective randomized clinical controlled RSA trial. Knee, 2014. 21(2): p. 396-401.

14. Ledin, H., P. Aspenberg, and L. Good, Tourniquet use in total knee replacement does not improve fixation, but appears to reduce final range of motion. Acta Orthop, 2012. 83(5): p. 499-503.

15. Ryd, L., et al., Roentgen stereophotogrammetric analysis as a predictor of mechanical loosening of knee prostheses. J Bone Joint Surg Br, 1995. 77(3): p. 377-83.

16. Nelissen, R.G., et al., RSA and registries: the quest for phased introduction of new implants. J Bone Joint Surg Am, 2011. 93 Suppl 3: p. 62-5.

17. Pijls, B.G., et al., Early migration of tibial components is associated with late revision: a systematic review and meta-analysis of 21,000 knee arthroplasties. Acta Orthop, 2012. 83(6): p. 614-24.

18. Stetzelberger, V., U. Obertacke, and A. Jawhar, Tourniquet application during TKA did not affect the accuracy of implant positioning: a randomized clinical trial. Knee Surg Sports Traumatol Arthrosc, 2017.

19. Dennis, D.A., et al., Does Tourniquet Use in TKA Affect Recovery of Lower Extremity Strength and Function? A Randomized Trial. Clin Orthop Relat Res, 2016. 474(1): p. 69-77.

20. Harsten, A., et al., Tourniquet versus no tourniquet on knee-extension strength early after fast-track total knee arthroplasty; a randomized controlled trial. Knee, 2015. 22(2): p. 126-30.

21. Smith, T.O. and C.B. Hing, Is a tourniquet beneficial in total knee replacement surgery? A meta-analysis and systematic review. Knee, 2010. 17(2): p. 141-7.

22. Schnettler, T., N. Papillon, and H. Rees, Use of a Tourniquet in Total Knee Arthroplasty Causes a Paradoxical Increase in Total Blood Loss. J Bone Joint Surg Am, 2017. 99(16): p. 1331-1336.

23. Ricciardi, B.F., et al., Patient and Perioperative Variables Affecting 30-Day Readmission for Surgical Complications After Hip and Knee Arthroplasties: A Matched Cohort Study. J Arthroplasty, 2017. 32(4): p. 1074-1079.

24. Horlocker, T.T., et al., Anesthetic, patient, and surgical risk factors for neurologic complications after prolonged total tourniquet time during total knee arthroplasty. Anesth Analg, 2006. 102(3): p. 950-5.

25. Wakankar, H.M., et al., The tourniquet in total knee arthroplasty. A prospective, randomised study. J Bone Joint Surg Br, 1999. 81(1): p. 30-3.

26. Zhang, W., et al., The effects of a tourniquet used in total knee arthroplasty: a meta-analysis. J Orthop Surg Res, 2014. 9(1): p. 13.

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Sekundaarinen patellapinnoitus polven tekonivelleikkauksen jälkeen – 101 potilaan tulokset Tekonivelsairaala Coxasta

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Secondary patellar resurfacing (SPR) is a procedure which can be used with patients suffering from persistent anterior knee pain after total knee arthroplasty (TKA). In this retrospective study our aim was to examine the effectiveness of SPR in alleviating anterior knee pain after TKA. We examined 101 patients who had undergone SPR at our institution between 2009 and 2016. Their medical records were reviewed for overall satisfaction after procedure, range of knee motion and pain improvement after SPR. Persistent pain after TKA was the prominent indication for the procedure in 61.4% of the cases, and 72.3% of these patients had anterior knee pain. 47.5% of all of the patients were fully satisfied with the outcome of SPR and additional 19.8% described their state as better than before the procedure. However, 30.7% of the patients were not satisfied and still suffered from anterior knee pain and other symptoms after SPR. Although most patients described their postoperative state as better than before SPR, only 38.6% of them had no symptoms after the procedure and 60.4% were left with some residual symptoms such as pain or stiffness. Further research is needed to identify those patients who are most likely to benefit from SPR.

Johdanto

Sekundaarinen patellapinnoitus on toimenpide, joka voidaan tehdä polven tekonivelleikkauksen jälkeen pitkäaikaisesta anteriorisesta polvikivusta kärsiville potilaille. Ensileikkauksessa tehtävän patellan pinnoituksen syynä voivat olla potilaan ikä, patellan anatomia sekä nivelruston laatu [1]. Pinnoittamista voidaan harkita myös, jos leikkauksen yhteydessä huomataan patellan huono kulku femurkomponentin urassa. Patellan ollessa hyvin ohut tulisi päällystämiseen suhtautua erityisen kriittisesti murtumariskin vuoksi.

Ensimmäiset polven tekonivelleikkaukset keskittyivät tibiofemoraaliniveleen, eikä patellaa yleensä päällystetty. Patellofemoraaliniveleen kohdistuvien merkittävien komplikaatioiden sekä polven etuosan kiputilojen yleisyyden myötä patellaan alettiin kiinnittää enemmän huomiota [2]. Tällöin polven tekonivelen femurkomponentin ja patellan välistä nivelpintaa alettiin muotoilla. Myöhemmin 1980-luvulla patellaa alettiin pinnoittaa metallipohjaisella tai polyetyleenipinnoitteella [3]. Pinnoittamisesta seurasi runsaasti komplikaatioita ja 50% kaikista polven tekonivelleikkeen liittyvistä ongelmista johtui patellan päällystämisestä [2].

Nykypäivänä Yhdysvalloissa 82% ja muualla maailmassa 35% patelloista pinnoitetaan polven tekonivelleikkauksen yhteydessä tai erillisessä uusintaleikkauksessa [2]. Suomessa patellan pinnoitus määräytyy usein ortopedin henkilökohtaisen mieltymyksen mukaisesti: Osa ortopedeistä ei koskaan pinnoita patellaa, osa selektiivisesti ja osa aina [4]. Päällystämispäätökseen vaikuttavat kliinisten olosuhteiden lisäksi sairaalakohtaiset erot.

Patellan pinnoittamisen hyödyllisyyttä pidetään

yhä kiistanalaisena [5]. Pinnoituksen vaikutusta polvitekonivelleikkauksen tuloksiin ja anteriorisen polvikivun hoitoon on tutkittu paljon, mutta yksiselitteistä käsitystä pinnoituksen hyödyllisyydestä ei ole saatu. Patellan pinnoittaminen kokotekonivelleikkauksen yhteydessä voi mahdollisesti pienentää uusintaleikkausriskiä [9]. Toisaalta rutiininomainen pinnoittaminen lisää myös kustannuksia ja murtumakomplikaatioita.

Yleisesti ottaen potilaiden tyytyväisyys lopputulokseen patellan sekundaarisen pinnoituksen jälkeen vaihtelee 40-90% välillä [6]. Tutkittaessa potilaiden tyytyväisyyttä toimenpiteeseen 65% kertoi olevansa tyytymätön toimenpiteen tulokseen ja 59% ei kokenut saaneensa lievitystä kipuunsa [7]. Tyytymättömillä potilailla kokotekonivelleikkauksen ja sekundaarisen patellapinnoituksen välillä oli lyhyempi aika kuin operaatioon tyytyväisillä ja heidän patellansa oli röntgenkuvassa kallistunut lateraalisesti aksiaalisessa suunnassa [8]. Anteriorisen polvikivun syynä voi olla polven tekonivelkomponenttien virheasento ja virheasennon korjaaminen saattaakin johtaa parempaan lopputulokseen kuin pelkkä patellan pinnoittaminen [7].

Tämän tutkimuksen tavoitteena oli saada tietoa sekundaarisen patellapinnoituksen hyödyllisyydestä ja vaikuttavuudesta Tekonivelsairaala Coxassa leikatuilla potilailla vuosina 2009-2016.

Aineisto ja menetelmät

Tutkimuksemme on retrospektiivinen kohorttitutkimus. Tutkimuksen aineistona käytettiin vuosina 2009-2016 Tekonivelsairaala Coxassa tehtyjä uusintaleikkauksia, joissa potilaalle on tehty sekundaarinen patellapinnoitus. Tutkimuksesta poissuljettiin potilaat, joille oli leikkauksen yhteydessä tehty jokin muu toimenpide sekä potilaat, joista saatava tieto oli vajavaista. Lopullinen aineistokoko oli 101 potilasta.

Sairauskertomustietojen ja Coxan tekonivelrekisteriin kerättyjen tietojen perusteella arvioitiin leikkauksen vaikutusta kipuun, toimintakykyyn ja polven liikkuvuuteen, sekä potilaiden tyytyväisyyttä leikkauksen tulokseen. Tarkasteltavat muuttujat jaettiin pre-, peri- ja postoperatiivisiin muuttujiin. Tutkittavista muuttujista tarkasteltiin etenkin postoperatiivisia oireita sekä potilaiden tyytyväisyyttä leikkauksen jälkeen. Selittävinä muuttujina käytettiin muun muassa leikkausindikaatiota, kipua provosoivia tekijöitä sekä kivun laatua.

Tilastollinen analyysi suoritettiin SPSS-ohjelmalla. Kategoristen muuttujien analysoimisessa käytettiin ristiintaulukointia sekä Fisherin eksaktia testiä. Jatkuvia muuttujia analysoitiin t-testiä käyttäen.

Tulokset

Alkuperäisessä aineistossa oli 103 potilasta, joista kaksi poissuljettiin vajavaisten tietojen sekä heille tehtyjen muiden toimenpiteiden vuoksi. Lopullisen aineiston muodostivat 101 peräkkäistä potilasta. Potilaiden iän keskiarvo oli 67 vuotta (SD x.y), BMI:n keskiarvo 30,6 (SD x.y) ja heistä 60 (59,4%) oli naisia. Tutkittavien potilaiden leikkausindikaatioina olivat kipu (48.5% tapauksista), selvä mekaaninen oireilu kuten kipu, rahina ja epävakaus (35.6%), kipu ja rahina yhdessä (12.9%) sekä muut syyt (2.0%) (Taulukot 1-2).

Kivusta kärsivistä potilaista 72.3%:lla kipu paikantui polven anterioriseen osaan ja 12.9%:lla muualle. 44.6% kertoi kivun provosoituvan patellofemoraalinivelelle (PF-nivel) tyypillisistä syistä (istumasta nouseminen, portaat, mäkikävely). 18.8%:ssa tapauksista kipua tuntui sekä rasituksessa että levossa. Ennen SPR:ää otetussa Laurinin projektiossa PF-nivel oli inkongruentti (lateralisoitunut) 13.9%:ssa tapauksista. PF-nivelen artroosimuutoksia oli havaittavissa 9.9%:lla tapauksista. Postoperatiivisia komplikaatioita ilmaantui 13 potilaalle, joista 7.9%:lla oli vuotava haava ja 5.0%:lla infektio. Uusintaleikkaukseen päädyttiin kahdeksan potilaan kohdalla.

Potilaista 47.5% oli täysin tyytyväisiä toimenpiteeseen ja 19.8% kertoi tilansa olevan parempi kuin ennen leikkausta. 38.6%:lla polvi oli leikkauksen jälkeen oireeton ja leikkauksen avulla oli saatu helpotusta kipuun.

30.7% potilaista kertoi olevansa tyytymättömiä leikkaukseen, eivätkä kokeneet leikkauksen tuoneen helpotusta kipuihin. 60.4%:lla potilaista oli jäännösoireita, kuten kipua ja polven jäykkyyttä leikkauksen jälkeen.

Preoperatiivisen polven anteriorisen kivun (verrattuna muuhun polven alueen kipuun) sekä postoperatiivisen tyytyväisyyden yhteyttä testattiin Fisherin eksaktilla testillä ja ristiintaulukoimalla mutta tilastollisesti merkitsevää yhteyttä ei havaittu (p=0.603). Myöskään muiden tutkittavien muuttujien (ikä, BMI, PF-nivelen lateralisointi, kivun

Table 1. Demographics (Preoperative information)

	(%)	*n*
Mean age (66.55)		
< 50	1	(1.0)
50-60	26	(25.7)
60-70	37	(36.6)
70-80	27	(26.7)
> 80	7	(6.9)
Gender		
Male	41	(40.6)
Female	60	(59.4)
BMI		
18,5-25	12	(11.9)
25-30	31	(30.7)
30-35	27	(26.7)
35-40	10	(9.9)
>40	5	(5.0)
Missing values	16	(15.8)
Indication		
Pain only	49	(48.5)
Mechanical symptoms	36	(35.6)
Stiffness and pain	13	(12.9)
Other Pain	2	(2.0)
Anterior	73	(72.3)
Other	13	(12.9)
Type of pain		
Anterior knee pain	45	(44.6)
Constantly painful knee	22	(21.8)
Other nonspecific symptoms	6	(6.0)
PF-joint incongruent in mountain view radiographs		
Yes	14	(13.9)
No	86	(85.1)
Missing values	1	(1.0)
Osteoarthritis in the PF-joint		
Yes	10	(9.9)
No	90	(89.1)
Missing values	1	(1.0)

syy ym.) sekä leikkauksen jälkeisen tyytyväisyyden välillä ei havaittu tilastollisesti merkitsevää yhteyttä ($p>0.05$ kaikissa vertailuissa).

Pohdinta

Tutkimuksemme tavoitteena oli selvittää sekundaarisen Tekonivelsairaala Coxassa tehtyjen patellapinnoitusten tulokset sekä potilaiden tyytyväisyys leikkaustulokseen. Vaikka suurin osa potilaista (67.3%) koki tilansa parantuneen leikkauksen myötä, noin kolmasosa potilaista oli kuitenkin tyytymättömiä toimenpiteeseen. On myös huomattava, että 60%:lla potilaista oli SPR:n jälkeen edelleen jäännösoireita. Postoperatiivisen tyytyväisyyden sekä tutkimuksessa käytettyjen muuttujien välillä ei havaittu tilastollisesti merkitsevää yhteyttä.

Table 2. Peri- and postoperative results.

	(%)	*n*
Patellar motion (perioperatively)		
Congruent	89	(88.1)
Congruent but rasps	2	(2.0)
Lateralized	7	(6.9)
Missing	3	(3.0)
Complication		
None	85	(84.2)
A bleeding wound/hematoma	8	(7.9)
Infection	5	(5.0)
Satisfaction		
Satisfied with the outcome	48	(47.5)
Better than before surgery	20	(19.8)
Disstatisfied	31	(30.7)
Outcome not known	2	(2.0)
Postoperative symptoms		
No symptoms	39	(39.0)
Residual pain	40	(40.0)
Mechanical symptoms (may also include pain)	7	(7.0)
Instability of the knee	3	(3.0)
Stiffness (may also include pain)	8	(8.0)
Other residual problems	3	(3.0)
Missing	1	(1.0)
Postoperative change		
No symptoms (pain etc.)	39	(38.6)
Residual symptoms (e.g. pain, stiffness etc.)	61	(60.4)
Missing	1	(1.0)

Tutkimuksen vahvuuksia olivat sen keskittyminen vain yhteen sairaalaan (Tekonivelsairaala Coxa). Leikkaukset on tehty yhtenäisillä indikaatioilla ja leikkaustiedot ovat kattavat. Tutkimuksen heikkouksia ovat sen retrospektiivinen luonne sekä pieni aineisto (101 potilastapausta), sekä vertailuryhmän puute.

Aiemmissa tutkimuksissa potilaiden tyytyväisyys toimenpiteeseen on vaihdellut suuresti ja ollut 40-90% välillä [6], mikä on linjassa tutkimuksemme tulosten kanssa. Sekundaaristen patellapinnoitusten yleisyys vaihtelee suuresti eri valtioiden, sairaaloiden ja ortopedien välillä [2,4]. Nykytiedon valossa patellan rutiininomaista pinnoittamista ei pidetä suositeltavana [2,5,7]. On myös huomattava, että osalle potilaista jää polven etuosan kipua TKA:n jälkeen riippumatta siitä, onko patella pinnoitettu vai ei. Sekundaarinen patellan pinnoittaminen on tämän tutkimuksen ja aiemman kirjallisuuden perusteella toimenpide, joka auttaa vain osaa potilaista, merkittävällä osalle potilaista jää SPR:n jälkeenkin jäännösoireita ja noin kolmasosa on selvästi tyytymätön toimenpiteen tulokseen.

Yhteenvetona toteamme, että sekundaarinen patellan pinnoitus on parhaimmillaan hyödyllinen toimenpide polven etuosan kivusta kärsiville potilaille primaarin TKA:n jälkeen. Ongelmalliseksi asian tekee se tosiasia, että potilasvalinta on hankalaa ja tekonivelleikkauksiin keskittyneiden ortopedien indikaatioasettelullakin n. 30% ei kokenut lainkaan hyötyvänsä toimenpiteestä. Tästä aiheesta tarvitaan selkeästi lisätutkimusta, jotta toimenpide osattaisiin paremmin kohdentaa siitä todennäköisimmin hyötyville potilaille.

Viitteet

1. Burnett RS, Bourne RB. Indications for patellar resurfacing in total knee arthroplasty. Instr Course Lectr. 2004;53:167-168.

2. Cameron-Donaldson ML, Ifran NN, Budhiparama NC. Selective patellar resurfacing with or without denervation as the ultimate answer: current concepts. Jisakos 2016;1:311–315.

3. Aglietti P, Insall JN, Walker PS, Trent P. A new patella prosthesos. Design ans application. Clin Orthop Rel Res. 1975;107:175-187.

4. Franck F, Ouanezar H, Jacquel A, Pibarot V, Wegrzyn J. The predictive factors of secondary patellar resurfacing in computer-assisted total knee arthroplasty. A prospective cohort study. Int Orthop 2017; https://www.ncbi.nlm.nih.gov/pubmed/28889222

5. Abdel MP, Parratte S, Budhiparama NC. The patella in total knee arthroplasty: to resurface or not is the question. Curr Rev Musculoskelet Med 2014; 7:117–124

6. Bhattee G, Moonot P, Govindaswamy R, Pope A, Fiddian N, Harvey A. Does malrotation of components correlate with patient dissatisfaction following secondary patellar resurfacing? Knee 2017;21:247-251

7. Toro-Ibarguen AN, Navarro-Arribas R, Pretell-Mazzini J, et al. Secondary patellar resurfacing as a rescue procedure for persistent anterior knee pain after primary total knee arthroplasty: do our patients really improve? J Arthroplasty 2016;31:1539–1543.

8. P. Scheurer, I. H. Reininga, H.-P. van Jonbergen, J. J. van Raay. Secondary patellar resurfacing following total knee arthroplasty: A cohort study in fifty eight knees with a mean follow-up of thirty one months. Int Orthop 2015;39:1301-1306.

9. Fu Y, Wang G, Fu Q. Patellar resurfacing in total knee arthroplasty: a meta-analysis. Knee Surg Sports Traumatol 2011;19:1460–1466.