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Hyvät kollegat!

Uusi vuosi on saatu alkuun ja Suomen Ortopediyhdistyksen toiminta jatkuu aktiivisena. Vuoden 2014 Ortopedian ja Traumatologian päivät muodostuivat jälleen menestykseksi ja koulutusta on tarjolla runsaasti tänäkin vuonna. Ajankohtaisin aihein varustettu SOY:n kevätkokous järjestetään 21.– 22.5.2015 Jyväskylässä.

Käsissänne on uunituore Suomen Ortopedia ja Traumatologia –lehden 1/15 numero. Tämä numero sisältää perinteikkään Itävallan kurssin luentolyhennelmät. Nyt järjestettävän XVII Itävallan kurssin koulutusohjelma on totuttuun tapaan korkeatasoinen ja myös lehdestä muodostui tiivis asiapaketti. Kiitos siitä kuuluu kurssin järjestäjille sekä laadukkaiden artikkelien kirjoittajille.

Yhdistyksemme vahvistunut taloudellinen tilanne on mahdollistanut aiempaa paremmat mahdollisuudet apurahojen jakoon. Muistutankin tutustumaan uudistuneisiin apurahojen myöntämisen periaatteisiin. Tarkemmat tiedot apurahoista löytyvät yhdistyksen verkkosivuilta.

Jäsenviestintää hoidetaan entistä enemmän sähköisesti. Jäsenrekisterimme on Suomen Lääkäriliiton alaisuudessa. Toivomme, että ylläpidätte ajantasaisia yhteystietojanne Lääkäriliitossa. Yhteystietonne voitte päivittää osoitteessa www.laakariliitto.fi/tietoni. Lääkäriliittoon kuulumattomat voivat päivittää tietonsa osoitteessa sihteeri@soy.fi.

Helsingissä 12.1.2015

Ville Puisto
SOT-lehden päätoimittaja

ILMOITUS 1 Biomet Oxford

Etiology, Diagnosis and Treatment of Tendinous Knee Extensor Mechanism Injuries

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Quadriceps and patella tendon ruptures are uncommon injuries often resulting from minor trauma typically consisting of an eccentric contraction of the quadriceps muscle. Since rupture of a healthy tendon is uncommon such injuries usually represent the end stage of a long process of chronic tendon degeneration and overuse. Risk factors include age, repetitive micro-trauma, genetic predisposition and systemic diseases as well as certain medications. Diagnosis is often made based on history and clinical findings and can be complemented by US or MRI imaging. Accurate assessment in the acute stage is of utmost importance since the time interval between trauma and surgery is the main prognostic factor, with a delay in surgery over 3 weeks resulting in significantly poorer outcomes. Operative treatment with fixation through longitudinal transpatellar drill holes is the treatment of choice in the majority of acute cases. In chronic cases tendon augmentation with auto- or allograft should be considered. There is a wide range of postoperative treatment protocols available in the literature, ranging from early mobilization and full weight bearing to cast immobilization for 6–12 weeks. Keeping biological aspects of tendon healing in mind, we advocate the use of a removable knee splint or orthotic with fully protected weight bearing and limited passive mobilization over 6 weeks. Operative treatment of acute ruptures yields good clinical results with low rates of complications.

Introduction/etiology

Disruption of the extensor mechanism of the knee joint can be of bony or tendinous origin. Patellar fractures are 2–3 times more common than quadriceps tendon ruptures, that in turn are 2–3 times more common than patellar tendon ruptures (1,2). It is generally accepted that rupture of a healthy tendon is very uncommon. Tensile overload of the extensor mechanism usually leads to a transverse fracture of the patella, which is considered the weakest link of the extensor mechanism (3). Patellar or quadriceps tendon rupture due to indirect trauma is in most cases the end stage of long-standing chronic tendon degeneration. Risk factors include age, repetitive micro-trauma, genetic predisposition and systemic diseases as well as certain medications (4). Kannus et al evaluated 891 biopsy specimens of spontaneously ruptured tendons (including 82 patellar and quadriceps tendons) and found that 97 % showed degenerative changes, whereas these changes were detected in only 35 % of intact tendons within age-matched control subjects (5).

The most common mechanism of injury is of a sudden contraction of the quadriceps muscle on a flexed knee, leading to an eccentric contraction and subsequent disruption of the extensor mechanism. Ciriello performed a systematic literature review in 2012 and reported that most quadriceps tendon ruptures are caused by a simple fall (61,5 %) or a fall down stairs (23,4 %) (6). Other mechanisms such as rupture during sports activities (6 %), car-accidents (3,2 %), spontaneous ruptures (3,2 %) and agricultural injuries (2,3 %, mainly penetrating trauma) are quite rare. In about 14 % of all cases comorbidities such as diabetes, obesity, hyperparathyroidism, rheumatic diseases and steroid use where reported. Bilateral quadriceps tendon rupture is a rare entity often leading to a delay in diagnosis of an average of 65 days, due to more than

50 % of cases being missed on initial assessment (7). 64 % of these patients have predisposing comorbidities such as obesity (21.4 %) and diabetes (17,8 %) with half having more than one risk factor.

Patellar fractures are slightly more common in women, whereas the majority of tendon ruptures occur in males (1). Quadriceps tendon ruptures (QTR) are more commonly seen in patients older than 45 years (1,6,8,9) and are often associated with degenerative changes of the tendon (5). The rupture is typically situated 1–2 cm proximal to the superior pole of the patella (6), which corresponds to a relatively avascular region of the tendon (10). Patellar tendon ruptures (PTR) by comparison occur in patients who are younger (< 45y) and more active (1,11), and more commonly result from direct trauma (12–14), as well as iatrogenic injuries (15,16). The rupture site is most often in the proximal part of the tendon close to the inferior patellar pole (12–14). Technically, the term "patellar tendon" is a misnomer, since the "tendon" is actually a ligament connecting one bone (the patella) to another (the tibia).

Diagnostics

Quadriceps and patella tendon rupture diagnoses can usually be reached through a thorough history and clinical examination. In traumatic cases knee radiography is part of the basic diagnostics in order to rule out fractures. Clinical vigilance is required especially in spontaneous ruptures and the elusive bilateral cases.

History and clinical exam. The typical history for an extensor tendon rupture involves some kind of trauma, albeit much smaller than expected. It is typically indirect in nature, involving sudden eccentric muscle contraction while trying to avoid a fall and is felt as an intense pain (17). The clinical diagnostic triad includes: acute pain, inability to actively extend the knee and a palpable gap at the site of the rupture (11). Especially in QTR the extensor mechanism may still be partially working, due to an intact retinaculum and iliotibial tract, allowing for straight leg raising. The palpable gap might be masked by a posttraumatic hematoma particularly with delayed presentation. Clinical findings of quadriceps tendon ruptures can also include a low riding patella (patella baja). Due to the lesser amount of soft tissue surrounding the patellar tendon, the gap of a PTR is more clearly palpable. On inspection, a high riding patella (patella alta) is a common finding and it fails to follow the tibia on knee flexion.

Radiology. Radiological investigations include plain radiography, ultrasound and MRI (18). In cases of traumatic knee injury, plain radiography is part of the standard diagnostic protocol. Apart from fractures and avulsions, degenerative changes such as the Tooth sign as well as patella positioning are assessed. According to a study by Hardy et al, patella spurs are present in 79 % of quadriceps tendon ruptures, 27 % of patellar tendon ruptures and only 15 % of patella fractures (19). Insall-Salvati described a ratio between the length of the patella (LP) and the patella tendon (LT) as assessed from a lateral knee x-ray or sagittal MRI. If the quadriceps tendon is torn the index (TL:LP) is less than the physiological range of 0,74–1,5 whereas a patellar tendon rupture causes the ratio to be above the physiological range (20).

In cases where clinical assessment is deemed insufficient, ultrasonography is considered a reliable and inexpensive method to verify the diagnosis in acute as well as chronic cases and also helps differentiate partial from total ruptures (21–23). It also allows dynamic examination of the extensor mechanism and is not affected by metal implants.

Although MRI can be considered the gold standard imaging modality (24), it rarely provides additional information that would alter the choice of treatment. It is more expensive and not as easily available as ultrasound, but might provide additional information in some chronic cases concerning tendon quality and muscle atrophy/fatty degeneration. In addition, a recent study by McKinney showed a surprisingly high incidence of associated intra-articular knee injuries with 9,6 % in QTR and 30 % in PTR. Most common were ACL tears (18 %) and medial meniscus tears (18 %), with these injuries being more likely in high-energy trauma. In light of these findings, MRI should be considered in younger patients with high-risk mechanisms.

Treatment

Early operative repair is the treatment of choice in complete acute patellar and quadriceps tendon ruptures as well as in many partial and chronic cases. The main prognostic factor influencing outcome is timing of surgery and less so the choice of surgical technique (9). Most authors advocate surgical treatment within 2–3 weeks from trauma, with incidence of poor functional outcomes and the need for augmentation growing in delayed cases (9,11,25,26).

According to literature the most common surgical procedures, when treating tendinous knee extensor mechanism injuries, are fixation through patellar drill holes and simple end-to-end sutures (1,6,27–29). Fixation through patellar drill holes can be considered the gold standard in ruptures near the poles of the patella, whereas mid-substance tears have also been successfully treated with simple end-to-end sutures. Ciriello et al's literature review showed that 50% of quadriceps tendon tears are treated by patellar drill holes and 22,5 % by simple suture. No significant difference was noted in the outcome between these surgical techniques (6,9). Recently, repair using anchors instead of patellar drill holes has been described. Results from biomechanical studies failed to show notable differences between the anchor repair and patellar drill hole techniques (30), but no large clinical series or comparative studies are available to allow firm conclusions to be drawn. According to Hart et al, both fixations are sufficiently strong, but trans-osseous fixation is stronger with higher ultimate tensile load (31). Fixation through patellar drill holes has a longer track record and has been shown to be a reliable, inexpensive and straightforward procedure (23). The possible advantage of anchor fixation, however, is smaller skin incisions (25,32), and reduced operative time (25). Some authors recommend additional augmentation by cerclage wire, suture, or autogenous tendon graft bridging in patellar tendon repairs (22,33–36). Marder et al published a series of patellar tendon ruptures treated without augmentation and early mobilization with excellent results, putting the need for augmentation into question (37).

For delayed repair or re-ruptures of the quadriceps tendon, the Scuderi technique has been advocated to reinforce (23,38,39) and the Codivilla technique to lengthen the tendon (23,34). Delayed patellar tendon ruptures should be augmented by cerclage-like application of tendon autografts (semintendinosus or gracilis tendon) or allografts applied through transpatellar and transtibial drill holes (30,34,40).

Operative management of patellar and quadriceps tendon ruptures yields good clinical results with a low rate of complications. The reported rate of re-ruptures is 2 % with other complications including heterotopic ossification (6,9 %), deep venous thrombosis or pulmonary embolism (2,5 %) and superficial and deep infection (1,2 % and 1,1 %) (6).

Postoperative protocol

There is a wide range of postoperative treatment protocols suggested in the literature, ranging from early mobilization and full weight bearing to cast immobilization for 6–12 weeks. Based on current knowledge of the biological process of tendon healing as well as best clinical evidence available, immobilization should not exceed 6 weeks. Tensile stress is necessary to improve tendon biological and biomechanical characteristics and knee mobilization is indicated to avoid joint stiffness and reduce muscle atrophy (6). There is good evidence that where stable fixation in acute ruptures is achieved, early weight-bearing in extension and limited passive mobilization leads to good clinical results (13,36,37,40,41). In certain cases, a cerclage wire or suture can be added to provide additional stability during early mobilization.

Töölö Hospital Treatment Protocol

Diagnostics

In most cases, the history and clinical examination will lead to the right diagnosis. Patients able to perform straight leg raise should, if possible, also be asked to perform knee extension from 90 degrees of flexion. In traumatic injuries plain radiology is routine, while ultrasound is reserved for ambiguous cases. In the typical middle-aged patient with a low energy mechanism, MRI is not advocated in our opinion, as any additional injuries uncovered would not alter management. MRI is indicated only in younger patients with higher energy trauma or in cases with particular clinical suspicion for additional injuries.

Treatment

Based on available evidence and our clinical experience, we recommend early operative treatment for acute patellar or quadriceps tendon ruptures, ideally within 2 weeks of injury. Our standard procedure includes fixation of 2 tendon grasping (Kessler, Krakow or Bunnell) non-absorbable sutures (No 5 Fiber Wire or Etibond) through 3 longitudinal patellar drill holes. The drill holes are made using a 2 mm drill and should be a minimum of 1 cm apart. If a tourniquet is used, it is deflated before tightening of the sutures to allow maximal tendon lengthening. The stiches are tightened with the knee in extension and an intraop-

Table 1: Töölö hospital postoperative rehabilitation

Postoperative rehabilitation protocol
• 6 weeks protected full weight bearing using leg splint or locked hinged knee orthotic
• Immediate start of isometric quadriceps exercises
• Week 0-3: 0-45 degrees of active flexion and passive extension
• Week 4-6: Progression to 0-90 degrees of active flexion and passive extension
• 6 weeks: permission of straight leg raise exercises
• 8 weeks: stationary biking and water running
• 3 months: progressive quadriceps exercises
• 4 months: jogging
• 9 months: jumping and contact sports permitted

erative range of motion of 0–90 degrees should be achieved. The tendon ends and retinaculum on both sides can additionally be opposed using absorbable Vicryl 0 stiches. In cases with severe tendon fraying or questionable patient compliance, the tendon repair can be augmented using a relaxing suture (Fiber wire/ Ethibond or PDS cordel) as described by West et al (36). The relaxing suture is tightened with the knee in 30 degrees of flexion. We prefer utilizing absorbable (PDS cordel) suture material instead of cerclage wire, because of less soft tissue irritation and avoiding the need for implant removal. Before wound closure the correct alignment and tracking of the patella is verified using clinical and/or radiological means.

Rehabilitation

All knees are protected in a custom-made leg splint or locked hinged knee orthotic for a period of 6 weeks. We begin with isometric quadriceps exercises immediately and allow active flexion up to 45 degrees and passive extension up to 0 degrees within 1–2 days post-operatively for at least 3 times a day. The knee is maintained in extension at all other times and protected full weight bearing as tolerated is allowed. After 3 weeks, the flexion range is increased gradually aiming for 90 degrees by 6 weeks. After 6 weeks, straight leg raise exercises are initiated and free range of motion allowed. Stationary biking and water-running is utilized from 8 weeks on and progressive quadriceps exercises allowed at 12 weeks. Running is permitted at 4 months with jumping and contact sports restricted till 9 months. In our experience, a custom-made removable leg splint is better tolerated by patients as premade orthotics often fit poorly and can cause irritation around the operative wound leading to wound complications.

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Success of Treatment of Deep Infections Following Plate Fixation of Proximal Tibia Fractures

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Introduction

The current treatment of displaced proximal tibia fractures is open reduction and plate fixation (ORIF). Historically, ORIF was associated with infection rates of up to 88 % due to immediate fixation through swollen, compromised soft tissues. With contemporary techniques such as staged protocols and dual incisions, the infection rate has decreased significantly. However, there is limited data available on the current success of treatment following ORIF of proximal tibia fractures complicated by deep infection. The aim of this study was to determine the success of treatment of deep surgical site infections (SSI) after ORIF of proximal tibia fractures.

Materials and methods

A chart review of patients with ORIF treated proximal tibia fractures (AO/OTA type 41) that were admitted to our level I trauma center between 2004 and 2013 was performed. Hospital records, including operative reports and clinical notes, were reviewed. We classified infection as deep SSI when all of the following criteria were met simultaneously: clinical signs of SSI, positive bacterial cultures of wound specimens and osteosynthesis material visible or palpable in the wound. The patients with deep SSI constituted the study population and demographic data, details of the treatment, microbiological data and treatment success were assessed.

Results

The incidence of deep SSI was 5.2 % (34 of 655 patients). 28 patients had an early infection within two months from index surgery and 6 patients had a late infection. Mean age of patients was 55 (range 16 to 84) and 65 % were male. 15 (44 %) patients with deep SSI were smokers and only 4 (12 %) patients were diabetic. Six (18 %) patients had open fractures and 20 (59 %) patients had bicondylar fractures. The mean time from injury to definitive ORIF was 9 days and 21 (62 %) patients had a temporary spanning external fixator. 13 (38 %) patients developed compartment syndrome and underwent urgent four-compartment fasciotomy. 20 (59 %) of the deep SSIs were monobacterial, and the three most prevalent pathogens were S. aureus (9), S. epidermidis (5), and P. aeruginosa (2). 14 (41 %) infections were multibacterial. The mean number of surgical procedures in patients with deep SSI was 4 (range 2 to 9).

Of the 28 patients with an early infection, 10 patients were successfully treated with wound debridement with or without skin grafting. 16 patients required a muscle flap to cover the soft tissue defect after debridement. 24 of 28 patients healed after secondary operations. Five patients had hardware removed after clinical and radiographic fracture union. There was one early above knee amputation (AKA) in a patient with severe soft tissue injury and two delayed AKAs due to persistent infection after flap coverage. One patient died before fracture union for unrelated reasons. Of the 6 late infections, 5 were treated with hardware removal and debridement. One patient with non-union and substantial bone loss was treated with AKA. Overall, 12 % (4 of 34) of infections resulted in limb loss and all other infections were successfully treated.

Conclusions

In proximal tibia fractures, deep SSIs after contemporary ORIF techniques are rare. Early infections prior to fracture consolidation warrant aggressive soft tissue management with debridement and possible muscle flap coverage. Persistent infection after flap coverage poses a definite risk for limb loss. Delayed infections could be treated in most cases with debridement and removal of infected hardware.

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Minimal invasive dorsal plate osteosynthesis of the tibia - are nerves and vessels at risk? An anatomical study

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Purpose of this anatomic study was to develop a new and safe technique of minimal invasive dorsal plate osteosynthesis for tibia shaft fractures. Sixteen paired adult lower limbs of eight different cadaveric specimens were examined. Anatomical prebending for each plate was done. Plates were inserted percutaneously, following plate fixation the neurovascular bundle was dissected out. The distance between the neurovascular bundle (posterior tibial nerve, posterior tibial artery) and the plate was measured at two different positions. The distance to the origin of the flexor digitorum longus muscle and the arch of the soleus muscle was measured. The mean distance between the neurovascular bundle and the plate amounted 1,4 cm (±0,2 cm; 1,0–1,7 cm) at hole number six and 1,1 cm (±0,4 cm; 0,6–2,0 cm) at hole number ten. The nerve was never directly in contact with the plate. The flexor digitorum longus muscle had its origin along the plate and was between the plate and the neurovascular bundle in all cases. Dorsal percutaneous plate insertion is a safe and easy method for osteosyntesis of tiba shaft fractures. Especially in case of poor skin and soft tissue conditions this technique offers a good alternative.

Introduction

Stabilization of tibia fractures by using locking plates has become a standard procedure beside nail osteosynthesis (1–5). In particular metaphysic tibia fractures, with or without intra-articular involvement are appropriate for plating. Current systems like the LISS (Less Invasive Stabilisation System; Synthes GmBH, Switzerland) or the LCP metaphysical plates (Locking Compression Plate; Synthes GmBH) allow minimal invasive percutaneous plate insertion. These plates are locking internal fixator constructs allowing to bridge the fracture (6).

Minimal invasive plate osteosynthesis seems to be more advantageous for soft tissue and bone biology, nevertheless prolonged healing was observed in simple fracture patterns when a bridging plate technique was used (7). The proximal and distal metaphyseal areas of the tibia have a rich extraosseous blood supply provided primarily by branches of the anterior and posterior tibial arteries (8). No literature may be found dealing with the risk of nerve and vessel injury when performing dorsal minimal invasive plate osteosynthesis of tibia fractures.

Material and Methods

Sixteen paired lower limbs preserved according to Thiel's method were examined. This special embalming technique, which was developed over a 30-year –period, provides a close to life model through the preservation oft he original tissue colour, consistency and degree of transparency (9).

Extremities with arthrosis, evidence of trauma, or other pathological changes were excluded from the study. Pathological skeletal changes were detected by means of x-rays. On the basis of anthropological literature the length oft the tibia can be related to the body height of the specimen. On this account the tibia length was measured in all specimens. Referring to tibia measuring technique described in literature, we measured the distance between the edge of the medial condyle and the tip of the medial ankle (10).

In a ventral prone position, a dorso-medial five centimetre long skin incision was made proximally 1 cm below the posterior edge of the tibia. The fascia was incised at the medial border of the gastrocnemius muscle, the medial origin of the popliteus and soleus muscle were identified. The popliteus and soleus muscle were mobilised with a raspatory on the dorso-medial side of the tibia. The insertion canal was extended distaly along the dorsal side of the tibia using a raspatory, position of raspatory was checked by fluoroscopy. Distally a 3 cm long skin incision was made at the dorso-medlial edge of the tibia and the soft tissue was mobilised. The anatomy of the tibia was checked by fluoroscopy, individual anatomical prebending of a 12-holes LCP-Philos plate (Synthes GmBH) was done for each bone. A 12 hole LCP-Philos plate was used because there is no anatomical prebended plate for the posterior tibia existing and the LCP-philos plate had the best anatomical fitting to the proximal posterior surface of the tibia in our meaning. Following the LCP-Philos plate was inserted proximal submuscularly, directly in contact to the bone (Figure 1). The linea musculi solei was identified as an orientation mark for the right direction of the plate. The plate was advanced to correct position, and then checked by fluoroscopy in two different planes (Figure 2 and 3). The proximal end of the plate was fixed 1 cm distal to the tibia plateau using two self-drilling and tapping screws. Position of plate and screws was checked by fluoroscopy. The specimens were dissected in order to identify the relation between the neurovascular bundle and the plate (Figure 4). The distance between the neurovascular bundle (posterior tibial nerve, posterior tibial artery) and the plate was measured in millimetres using a sliding gauge. Measurements were done at the positions of holes number six and ten of the LCP-Philos-plate. The origin of the flexor digitorum longus muscle and the Arch of the soleus muscle were also measured. The tibia-length was measured between the edge of the medial condyle and the tip of the medial ankle (10).

The relation between the nerve and the plate was analyzed; all cases were documented by photography. Results were entered into a computerized database. All computations were done using Microsoft Excel® 2003, p-values below 0.05 were seen as statistically significant.

Results

A total of sixteen lower limbs of eight different specimens (4 male, 4 female; 8 right, 8 left) were investigated. Age of cadavers averaged 68.5 years (55–83 years). The length of the tibia averaged 39,8 cm (±1,3 cm; 37,6–42,0 cm). We documented the distance between the nerve and the plate at holes six and ten of the 12-holes Philos-plate. The mean distance between the neurovascular bundle and the plate was 1,4 cm (±0,2 cm; 1,0–1,7 cm) at hole number six of and 1,1 cm (±0,4 cm; 0,6–2,0 cm) at hole number ten. The flexor digitorum longus muscle had its origin along the plate (between holes 1 and 12) and was between the plate and the neurovascular bundle in all cases.

The arch of the soleus muscle was between the holes 3 and 5 and its origin was between the holes 3 and 10. Student's t-test failed to demonstrate a statistically significant correlation between the measurements, side and gender. The sample size however was too small.

Discussion

The use of minimally invasive techniques with angular stable plates is fast becoming popular with ever increasing indications. Usually closed reduction is done under fluoroscopic control, the plate is inserted via a small skin incision and the screws (in particular the distal screws) are inserted percutaneously. Intramedullary nailing still remains the treatment of choice for most uncomplicated diaphyseal fractures of the tibia, but minimally invasive plate osteosynthesis offers a reliable and reproducible technique in the treatment of closed unstable fractures of the distal tibia with intra-articular or peri-articular fracture extensions and proximal tibia fractures (1–7).

Various studies report about the antero-lateral plating technique of the tibia and relation between the plate and anatomical important structures like the deep and superficial branch of the fibular nerve and the dorsal artery of foot (11–15). Main disadvantages of the antero-lateral approach are the soft tissue coverage proximally and potential neurovascular irritations due to the plate distally (12). To date no literature

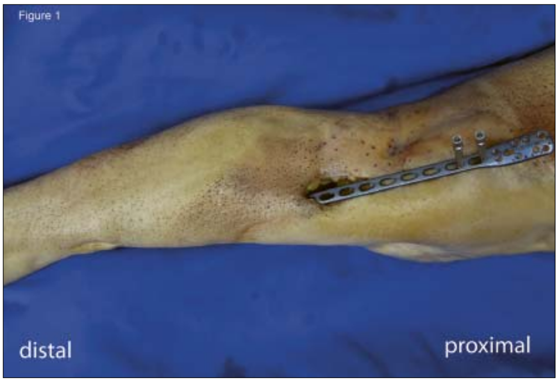

Figure 1: percutaneous minimal invasive insertion of Philos plate (cadaver specimen).

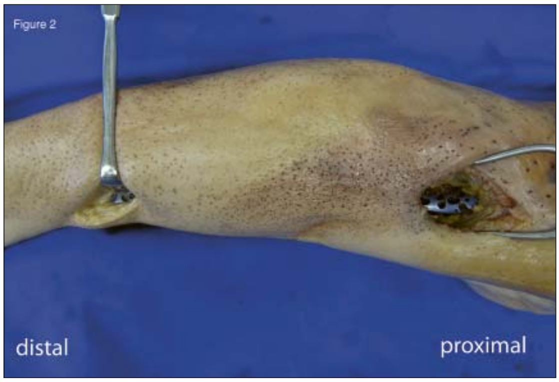

Figure 2: inserted plate, proximal and distal minimal invasive dorsal approach.

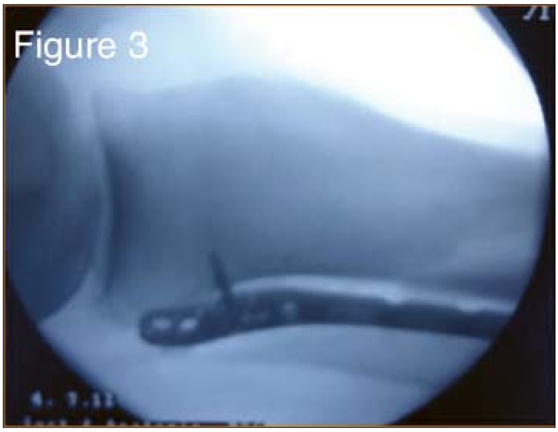

Figure 3: fluoroscopy of proximal tibia, checking position and prebending of the plate.

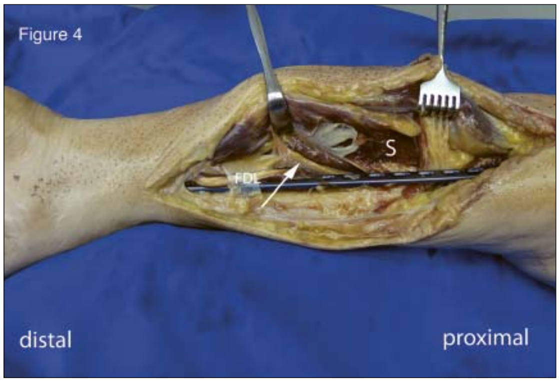

Figure 4: dissected specimen; S: soleus muscle, FDL: flexor digitorum longus muscle, arrow: neurovascular bundle.

may be found dealing with the risk of nerve and vessel injury when performing dorsal minimal invasive plate osteosynthesis of tibia fractures. The course of the posterior tibial nerve and the artery described in literature hypothesizes that the risk of iatrogenic injury caused by percutaneous dorsal plating is low (8). The proximal and distal approach to the dorsal tibia used in this anatomical study is well described in literature (16–18).

The findings of our study suggest that the risk of iatrogenic injury to the posterior neurovascular bundle is low. The tibial nerve and the artery were never in direct contact with the plate. The neurovascular bundle was always protected by the muscle belly of the flexor digitorum longus muscle. The risk of iatrogenic injury to the vas nutritium of the tibia is low, since this vessel courses lateral to the approach. This minimal invasive dorsal plating technique offers a good option particularly in case of proximal tibia fractures and poor skin and soft tissue conditions. Good soft tissue coverage of the plate may be achieved.

We conclude that dorsal minimal invasive plating of tibia fractures may be considered as a safe and easy method of osteosynthesis. In the injured patient, plate application may be more demanding due to the distorted anatomy resulting from the injury. In the same way the risk of iatrogenic soft tissue injuries may be increased. Exact preoperative examination of the leg is mandatory to exclude nerve, vessel, muscle and tendon injuries (19).

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The risk of neurovascular injury in Minimally Invasive Plate Osteosynthesis (MIPO) when using a distal tibia anterolateral plate: a cadaver study

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Percutaneous plating of the distal tibia via a limited incision is an accepted technique of osteosynthesis for extra-articular and simple intra-articular distal tibia fractures. In this study we identify structures that are at risk during this approach. Thirteen unpaired adult lower limbs were used for this study. Thirteen, 15-hole LCP anterolateral distal tibial plates were percutaneously inserted according to the recommended technique. Dissection was performed to examine the relation of the superficial and deep peroneal nerves and anterior tibial artery to the plate. The superficial peroneal nerve was found to cross the vertical limb of the LCP plate at a mean distance of 63 mm (screw hole five) but with a wide range of 21 to 105 mm. The neurovascular bundle (deep peroneal nerve and anterior tibial artery) crossed the plate at a mean of 76 mm (screw hole six) but also with a wide range of 38 to 138 mm. The zone of danger of the neurovascular structures ranges from 21 to 138 mm from the tibial plafond. In one specimen, a significant branch of the deep peroneal nerve was found to be entrapped under the plate. Caution is advised when using anterolateral minimally invasive technique for plate insertion and screw placement in the distal tibia due to great variability in the neurovascular structures that course distally in the lower leg and cross the ankle.

Introduction

Percutaneous plating of the distal tibia via a limited incision is an accepted technique of osteosynthesis for extra-articular and simple intra-articular fractures of the distal tibia. Depending upon fracture pattern, extent of soft tissue injury and coverage, an anterolateral minimally invasive approach to the distal tibia may be considered for osteosynthesis. With a relatively sparse soft tissue envelope, and great variability in neurovascular structures around the ankle, there is the potential for injury to the superficial peroneal nerve and the neurovascular bundle consisting of the deep peroneal nerve and anterior tibial artery. Wolinsky and Lee (1) previously described that the superficial peroneal nerve was not at risk when positioning an anterolateral plate in a retrograde manor over the distal tibia. In clinical practice we have found that it may be injured and the danger zone for placement of percutaneous screws is also larger then previously reported (1).

This study was performed to examine the neurovascular structures that are at risk when performing minimally invasive plate osteosynthesis (MIPO) for plating the anterolateral distal tibia.

Materials and Methods

Thirteen unpaired (7 right and 6 left) whole lower limb cadaveric specimens embalmed with the method of Thiel (2) were used. The mean age of the donors was 75 years (52 to 82) at the time of death. There was no evidence of previous injury, pathological changes or implanted prosthesis. The whole leg specimens were placed in a supine position to simulate patient position intra-operatively. The surgical approach utilized was as described by Bohler (3) whereby an anterolateral incision was made between the fibula and tibia distally in line with the 4th metatarsal. A 15-hole 3.5 mm LCP (Locking Compression Plate) anterolateral distal tibia plate (Synthes, Solothurn, Switzerland) was positioned in a retrograde fashion in a submuscular and extraperiosteal plane into its optimal position of fit upon the tibia. A small incision was made to position the proximal end of the plate upon the tibia towards the crest. The plate was secured distally with a Kirchner wire and proximally with a locking screw. Plate position was confirmed using an image intensifier with radiographs taken in orthogonal planes.

Further dissection was performed to identify the path of the superficial peroneal nerve and the neurovascular bundle consisting of the deep peroneal nerve and anterior tibial artery as they crossed the vertical and horizontal limbs of the 15-hole LCP anterolateral distal tibia plate. The structures were examined as they crossed the vertical limb of the plate as measured from the tibial plafond, and from the most lateral border of the tibia at the syndesmosis, as they crossed the horizontal limb of the plate. All distances were measured using a calibrated Vernier micrometer (Mitutoyu, Kawasaki, Japan) and recorded in millimetres, to an accuracy of ± 1 mm. The tibial length was also recorded as the distance between the centre of the medial joint line of the knee and the tip of the medial malleolus.

Table 1. Complete data set for the superficial peroneal nerve and neurovascular bundle crossing the vertical and horizontal limbs of a 15-hole LCP anterolateral distal tibia plate.

			Vertical limb of 15-hole LCP plate							
			Superficial Peroneal Nerve				Neurovascular bundle			
			Distance from tibial plafond (mm)				Distance from tibial plafond (mm)			
Patient	Side	Tibia length (cm)	Mean	Min	Max	Screw hole	Mean	Min	Max	Screw hole
1	R	37.6	77	72	83	6 to 7	65	61	72	5 to 6
2	R	33.7	73	61	83	5 to 7	63	61	72	5 to 6
3	L	36	65	47	93	4 to 8	47	38	61	3 to 5
4	L	31.2	61	38	72	3 to 6	116	94	138	8 to 12
5	R	36.3	25	23	28	1	64	47	83	4 to 7
6	L	41.7	48	25	83	1 to 7	94	83	105	9 to 7
7	R	40.4	23	21	25	1	72	61	83	5 to 7
8	L	36.2	49	31	83	2 to 7	61	47	72	4 to 6
9	L	33.5	61	47	72	4 to 6	93	83	105	7 to 9
10	L	38.8	97	80	105	7 to 9	38	38	38	3
11	R	37.4	79	62	94	5 to 8	116	105	127	9 to 11
12	R	32.2	96	83	105	7 to 9	94	83	105	7 to 9
13	R	34.3	70	61	83	5 to 7	61	61	61	Under 5
		Average	63	21	105		76	38	138	

Results

The complete sets of results are shown in table 1. The mean tibial length was 36.1 cm (31.2 to 41.7). All vertical measurements were from the tibial plafond (figure 1). The superficial peroneal nerve was found to cross the vertical limb of the LCP plate at a mean distance of 63 mm (screw hole five) but with a wide range of 21 to 105 mm (figure 2). This corresponded to screw holes one to nine. The neurovascular bundle crossed the plate at a mean of 76 mm (screw hole six) but also with a wide range of 38 to 138 mm. This corresponded to screw holes three to twelve.

Over the horizontal limb of the plate, measurements were made medially from the most lateral border of the tibia at the syndesmosis (figure 3). The superficial peroneal nerve had a variable course over all four screw holes (figure 4). The nerves crossed at a mean of 19 mm (screw hole three) and a range of 6 to 31 mm (screw holes one to four) from the lateral tibial edge. The neurovascular bundle had a slightly more lateral course, crossing at a mean of 24 mm (screw hole three) and a range of 8 to 43 mm (screw holes one to four) from the lateral tibial edge. In three of the specimens the anterior tibial artery coursed lateral to the plate. A large branch of the deep peroneal nerve was found to be entrapped under the plate in one specimen (figure 3).

Discussion

There are only limited studies that have been published regarding the risk to neurovascular structures using a minimally invasive approach to the distal tibia (1,4,5). MIPO offers attractive benefits; it protects the soft tissue envelope, potentially allows for a quicker operative time, and results in less soft tissue contusion and mobilization, with a concomitant potential for an improved healing process (6).

The superficial peroneal nerve, which is a branch of the common peroneal nerve, courses the anterolateral compartment of the leg. It pierces the deep fascia between 5 and 15 cm above the lateral malleolus, dividing distally into the medial and intermediate dorsal cutaneous nerves of the dorsum of the foot (7). There is great variability in the course of the nerve (8,9), and

	Horizontal limb of 15-hole LCP plate							
	Superficial Peroneal Nerve				Neurovascular bundle			
	Distance from lateral tibial margin (mm)				Distance from lateral tibial margin (mm)			
	Mean	Min	Max	Screw hole	Mean	Min	Max	Screw hole
	21	15	27	3	34	32	39	Lateral
	19	14	22	3	33	31	37	Lateral
	18	13	23	3	21	17	26	3
	22	18	26	3	20	21	28	3 to 4
	7	7	15	1	28	27	29	4
	13	6	29	1 to 4	24	19	27	3 to 4
	26	21	27	3 to 4	22	22	25	3
	25	21	28	3 to 4	29	27	31	4
	14	12	18	2	23	21	24	3
	20	17	23	3	32	32	43	Lateral
	16	12	21	2 to 3	20	19	29	3 to 4
	27	22	31	4	21	20	28	3 to 4
	23	22	25	3	13	8	19	Under 2 & 3
	19	6	31		24	8	43	

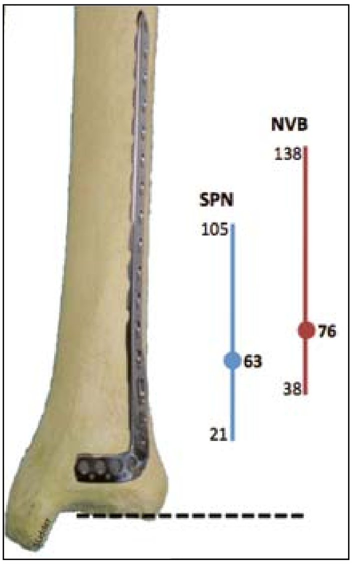

Figure 1. Diagram illustrating position of superficial peroneal nerve (SPN) and neurovascular bundle (NVB) above the tibial plafond (dashed line) and in relation to the distal tibia and 15-hole LCP distal tibia plate. Mean distance (in bold) and range illustrated. All values in millimeters.

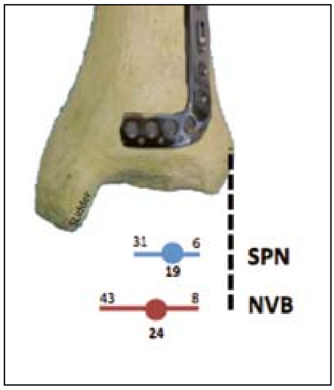

Figure 3. Diagram illustrating position of superficial peroneal nerve (SPN) and neurovascular bundle (NVB) crossing the horizinatal limb of the LCP distal tibia plate. Distances measured from lateral edge of tibia (dashed line) with mean values (bold number) and range in millimeters.

Figure 2. Photograph of superficial peroneal nerve (*) crossing obliquely over the vertical limb of the anterolateral distal tibia plate.

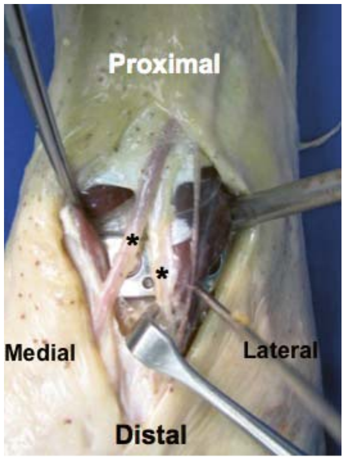

Figure 4. Photograph of superficial peroneal nerve (*) crossing over the horizontal limb of the anterolateral distal tibia plate.

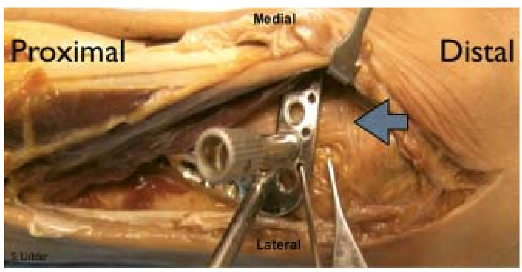

Figure 5. Clinical photograph of right distal tibia with LCP anterolateral distal tibia plate insitu. A branch of the deep peroneal nerve under the plate is shown (blue arrow).

this needs to be considered during percutaneous screw fixation when using the anterolateral distal tibia plate. In our study, we found that the nerve coursed obliquely, often over multiple screw hole positions. Wolinsky and Lee (1) previously recommended a non percutaneous approach in the area 40 to 110 mm above the distal incision when using Bohler's approach to the anterolateral distal tibia. This equates approximately to a zone from 70 mm to 140 mm proximal to the tibial plafond. In our study the superficial peroneal nerve was located between 21 to 105 mm from the tibial plafond. This extends the zone distally where care is needed for percutaneous screw fixation. In four of the 13 cadavers, the superficial peroneal nerve had already divided into the intermediate and medial cutaneous nerves above the level of the horizontal limb of the LCP distal tibia plate.

The neurovascular bundle consisting of the deep peroneal nerve and anterior tibial artery crossed the deep fascia more proximal then the superficial peroneal nerve, however again showed great variability in its course. It coursed in an oblique fashion from a proximal posterior to a distal anterior direction in a range 38 to 138 mm from the tibial plafond. Over the horizontal limb of the LCP plate, the anterior tibial artery crossed in nine out of 13 specimens over the third or fourth screw holes in a range between 8 and 43 mm from the lateral margin of the distal tibia.

This study demonstrates that great variability is present in both the superficial peroneal nerve and also the neurovascular bundle. Meticulous attention is needed during plate placement and placement of screws making sure that tissues are protected. The zone is which the neurovascular structures were present range from 21 to 138 mm from the tibial plafond, and also across most of the ankle in a horizontal plane. Although a submuscular and extraperiosteal technique was used to place the LCP plate, in one specimen a significant branch of the deep peroneal nerve was found under screw hole five of the vertical limb and screw holes two and three of the horizontal limb of the LCP plate (figure 5). Local anatomy may further be distorted with fractures of the distal tibia.

We agree with Wolinsky and Lee (1), that the deep peroneal and anterior tibial artery are at risk as they course from a posterior position proximally to a more anterior position distally but due to great variability in the superficial peroneal nerve (7–9), this is also at risk.

There are some limitations to this cadaver study. The method of Thiel used for embalming allows excellent preservation of tissue but there may be some differences in the soft tissue characteristics compared with fresh frozen cadavers. We believe however that any differences to measurements of neurovascular structures would be minimal.

In summary, a minimally invasive technique for osteosynthesis has many benefits however due to the great variability in the course of the superficial and deep peroneal nerves and the anterior tibial artery, caution is advised when performed percutaneous screw placement. A more generous incision with adequate protection of the neurovascular structures would prevent injury to these structures.

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Osteotomies around the ankle

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Introduction

As 63 % of the patients with ankle joint arthrosis present with a malaligned hindfoot, corrective osteotomies around the ankle have gained increasing popularity for the treatment of early- and midstage arthrosis. However, recent studies indicate that asymmetric arthrosis of the ankle joint in a majority of cases is not only due to a single plane deformity, but may include a complex instability pattern involving the ankle joint, the neighbouring joints and the stabilizing surrounding soft tissues. Additionally, the deformity may be due to a malalignment above the ankle joint, below the ankle joint or it may be mid-/forefoot driven.

Aims of osteotomies

Hindfoot malalignment leads to a focal static and a dynamic overload within the ankle joint. Whilst standing, the center of force transmission is medialized in the varus ankle and lateralized in a valgus ankle. The forces within the joint are amplified by activation of the triceps surae: the Achilles tendon becomes an invertor in varus deformities and an evertor in valgus deformities respectively and thereby acts as an additional deforming force on the hindfoot. Subsequently the aims of a corrective osteotomy are to (1) realign the hindfoot, (2) transfer the ankle joint under the weight bearing axis and (3) normalize the direction of the force vector of the triceps surae.

Anatomical and biomechanical background

The ankle joint consists of three bones: the tibia, the fibula and the talus. These bones are held together by a complex ligamentous apparatus, maintaining tight joint contact throughout the entire range of motion. Therefore the principles of corrective osteotomies of the proximal tibia, i.e osteotomies around the knee (only two bones, limited osseous containment), cannot be transferred to the corrections of the ankle. In contrast to corrections of the proximal tibial articular joint surface, an isolated correction of the distal tibial articular surface angle (TAS) may not lead to normalization of the load distribution within the ankle joint. It has been shown that isolated changes of the TAS lead to a paradox shift of the loads in the ankle joint, i.e. acute varus deformities shift the loads laterally and valgus deformities shift the loads medially. This is also the case for calcaneal osteotomies, where the paradox shift has also been observed. Furthermore, ex vivo studies showed that changes of the TAS angle and calcaneus osteotomies shift the load transfer not only in a medio-lateral but also in an antero-posterior direction. Therefore the assessment of asymmetric ankle joint arthrosis and the planning of corrective measures must include both, the sagittal and the coronal plane.

Next to malalignment ligamentous instability has been shown to be a major risk factor for the development of ankle joint arthrosis. Different types of instability patterns can occur around the ankle joint. It is important to distinguish between isolated ankle joint instability and instability patterns involving not only the ankle joint but also the subtalar joint and/or the talonavicular joint. This 'balance board instability' may lead to a complex peritalar instability pattern.

Joint preserving procedure (JPS) or joint non-preserving?

- As the results of ankle arthroplasty are inferior to replacement of the other joints of the lower extremity osteotomies of the foot and ankle may be used more aggressively than for example around the knee.
- There are no comparative studies between JPS and arthrodesis / ankle replacements.

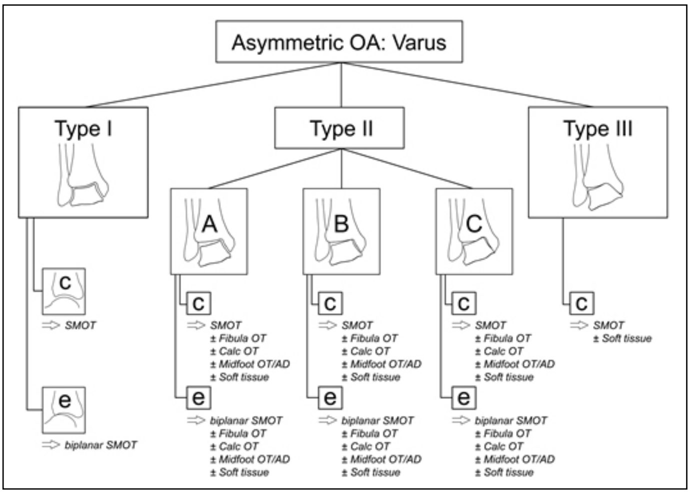

Figure 1. From Foot Ankle Int. 2011.

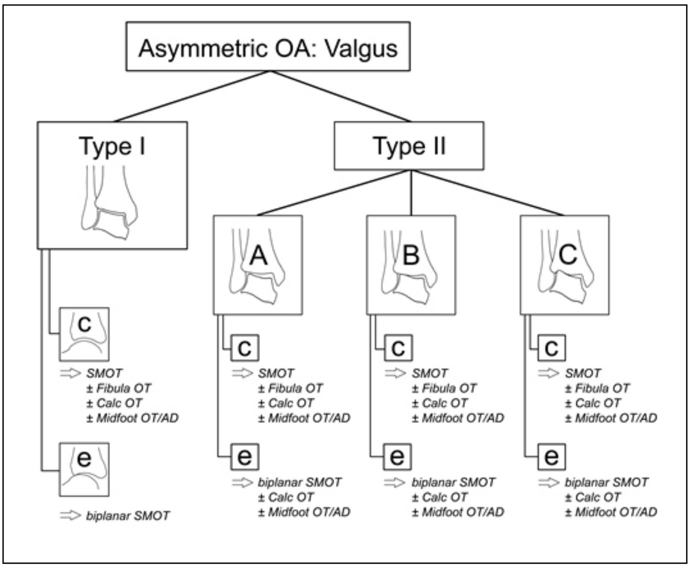

Figure 2. From Foot Ankle Int. 2011

- Advanced stages of arthrosis (Takakura stage IV) have been shown not to benefit from osteotomies only. However, both, ankle arthroplasty and ankle fusion, require a normally aligned hindfoot and a plantigrade foot. Therefore, alignment surgery may be indicated before arthroplasty.
- There is no indication for corrective osteotomies in a normally aligned foot and ankle.
- Generally corrective osteotomies are indicated in early and midstage asymmetric arthritis (medial/lateral or anterior/posterior), preserved range of motion in the joint and stable ligaments (consider ligament reconstruction).

Classification

For the outcome and the planning of JPS of the ankle joint two types of asymmetric ankle joint arthrosis need to be distinguished in the frontal plane: the congruent (Type I) and the incongruent type (= talus tilted within the ankle joint mortise; Type II). In the sagittal plane the wear pattern is analyzed in a similar fashion: congruent or incongruent wear (excessive degeneration anteriorly or posteriorly).

As the ankle is part of a kinematic chain, reconstruction may involve deformity correction proximal and distal to the ankle joint in combination with soft tissue reconstruction.

Technical annotations

The correction of the axis should be performed whenever possible in the center of rotatio (CORA). That means deformities above the ankle should be adressed by a supramalleolar osteotomy (SMOT), for those below the ankle a osteotomy of the calcaneus is recommended.

Another preoperative consideration affects the type of deformity. In incongruent joints with minor deformities a SMOT on the medial side is performed, for larger ones a lateral approach with simultaneous fibula osteotomy is the method of choice. Large deformities in congruent joints need a dome shaped osteotomy.

One possible pitfall can occur as performing calcaneus osteotomies due to paradox load shift in the ankle joint. Not least because of this fact, the deformity itself has to be studied with the adequate diagnostic tools, correction has to be planned meticulously and any possible side effect should be taken into consideration.

Conclusion

A majority of patients with posttraumatic arthrosis of the ankle joint present with a malaligned hindfoot. Alignment correction normalizes the intra-articular load distribution and thereby diminishes excessive asymmetric cartilage load. Furthermore, correction of the hindfoot axis prepares the configuration of the ankle joint in favor of a second surgery. For example, fusion or joint replacement procedures are known to profit from a well-aligned hindfoot.

Treatment of sequelae after ankle and pilon fractures

Additional annotations to the aforementioned explanations:

The treatment of sequelae after ankle and pilon fractures has frequently to deal with a high rate of posttraumatic (secondary) osteoarthrosis due to nonunion, malunion, malalignment or posttraumatic infection. We can differentiate between short-, mid- and longterm complications. In case of a treatment failure it is essential, to perform early revision before osteoarthrosis has reached stage III and it is still beyond dispute, that prevention would be the best treatment. The goals of a reoperation are to stabilize the fracture if unstable, restore joint congruency, to achieve correction of alignment and to ensure ligament balancing. The treatment options include adequate diagnostic measures as well as solid, appropriate implants. Sometimes it can be necessary to include (vascularised) bone grafts in combination with correction osteotomies. At last we should consider a staged approach especially in cases with delicate skin and soft tissue situation.

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Longitudinal peroneal tendon rupture – Aetiology and treatment

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Introduction

Injury for peroneus tendons is rare but it coexists with the most common sport injury; simple ankle twist. Blood supply, instability, enlargement of peroneus tubercle, chronic luxation or subluxation of peroneus tendon, low muscle belly of peroneus brevis, peroneus quintus tendon and hind foot varus are among associated diagnosis that can occur together with peroneus tear (1,2). Tennis, soccer skiing, american football, running, ice-skating and basket are common among the sports in which tears occur. Ruptures has been reported in classical balet dancers as well (3). The most important key for good clinical result is correct clinical diagnosis.

Anatomy

Peroneus longus muscle origin from posterolateral part of proximal fibula extending to the two thirds of the fibula. Peroneus brevis a bit lower from the lower two thirds of fibula and is situated slightly anterior and medial to longus. Their tendons run and turn behind lateral malleolus in peroneal groove in a common tendon sheath. Peroneus brevis more oval shaped located more anteriorily between lateral malleolus and longus tendon more rounded in cross-sectional shape. Tuberculum peronei acts as a traffic triangle and quides brevis tendon anteriorily towards its insertion at the base of fifth metatarsus. Longus is directed posterior to peroneal tubercle and twists there inferiorily, medially and distally in peroneal groove of cuneiform bone and finally dives and inserts at the base of plantar aspect of medial cuneiforme bone. It twists three times during its course making it vulnerable for ruptures. Blood supply for both tendons is worst just behind the tip of lateral malleolus and for longus at the groove of cuneiform bone.

Function

Peroneus muscles function as dynamic stabilizers of the ankle. They produce 63 % of ankle eversion and 4 % plantar flexion power. They are important in the ankle propriocepcion, whether lateral ligaments are intact or not. However, brevis and longus have different functions. Brevis being more powerful in plantar flexion and longus is more important in pronation and eversion. Brevis acts as the most powerful abductor of the ankle. (4).

Etiology of tears

Peroneus tendons can be injured in an acute trauma or with chronic stress. If the tendon is healthy the trauma must be powerful. Pure acute traumatic ruptures are rare. Most often the injuries occur on a acute-on-chronic basis. Brevis injured more often than longus. Chronic injuries include tendinitis, tenosynovitis, tendinosis and tendinopathia. Tendinopathia and chronic longitudinal tears are often cause by repeptitive mechanical stress, like long distance running (5,6,7,8). The brevis is mechanically grinded between longus and lateral malleolus. Instability of lateral ligaments of the ankle and repetitive inversion injuries can cause partial longitudinal tears. Total ruptures are rare. Acute rupture of peroneus longus should be suspected with acute onset of pain at inferolateral corner of foot.

It has been postulated that chronic stenosing synovitis at the level of peroneal tubercle might jam the movement s of the tendons and cause stress behind and under lateral malleolus resulting tendon tears (peroneal tuberculum impingement).Chronic or acute luxation or subluxation of peroneus tendons can be reason for fraying and split tear within the tendon (9). Hindfoot varus includes in the associated pathology of peroneus tendon tears (1). Sometimes even peroneus quartus (present in 6.6 to 21.7 % of individuals) can make the peroneal tunnel too crowded, causing pressure on specially to brevis and being part of the trauma cascade (2). DM, RA and arthropathies together with time can make the tendon more prone to injury.

Incidence of tears

The incidence of peroneus tears range from 11 to 37 % in cadaver studies. In our own study, while performing operation on 520 instable ankles, we found a tear in 46 peroneus brevis and 20 longus tendons. In 5 patients both tendons were ruptured. Of these operated ankles, tear was found in 15,5 % of the ankles. In an other study it was found that while treating 38 peroneus tendon injuries operatively, the peroneus lesion was associated with ankle instability in 50 % of the cases (8). While operatively treating peroneus injuries Dombek et al. found that most common cause was ankle sprain or other traumatic injury (58 %)(10). They observed a brevis tear seven times more often than a longus tear.

Symptoms and diagnostics

Patient complains on pain and swelling laterally in the foot. 43 % of patiens complain of instability (1). Typical symptoms are swelling and pain under and behind the lateral distal fibula. Pain at palpation and sometimes a palpable mass can be present. Pain can be provocated my resisted hindfoot eversion and ankle dorsiflexion or using passive hindfoot inversion and ankle plantaflexion. While peroneal tuberculum impingment is present the mass can be felt more distally as well as pain. Hindfoot and forefoot alignment is evaluated with the patient standing. Always check the balance ond coordination with standing single- or double-heel rise. The stability of the ankle should naturally be evaluated. Anamnesis and clinical signs are the most reliable findings for the diagnosis. Swelling and posterolateral pain are the key for the diagnosis. Most often when there is swelling around the tendon you will find a tear during operation. With regard to peroneus longus, tear should be suspected with acute onset of pain at the inferolateral aspect of the foot. The diagnosis can be verified with the help of ultrasound or even MRI, for both an experienced radiologist is needed. Nevertheless, the diagnosis of peroneus tendon tears must rely on anamnesis and clinical examination.

Treatment

Non-operative treatment is commenced when the diagnosis is first made. Corticosteroid injection is not indicated unless it has been proved that there is no tendon tear present. Anti-inflammatory drugs, ice and rest from resulting activity are indicated. Lateral wedge can be helpful as well as treating instability with a brace. Concentric and extrinsic training therapy is needed for both tendons with the guidance of physiotherapist. Not often this is helpful and an operation is needed.

Operative treatment can be considered if tendon tear is present clinically and verified with either US or MR and the symptoms have continued for more than 3 months. A split tear is difficult to heal, specially in brevis and have a tendency to grow larger due time, especially for brevis tendon. Operation plan must be carefully designed for each patient individually and the final decision between partial resection and saturation and tubularisation or even both can be made not until at operation. Instability and impingement must be corrected at the same time with surgical revision and repair of the injured tendon. An instable tendon should naturally be stabilized at the same time. Ligamentoplasty must be considered with regard to instability.

Conclusions

The most common complication of peroneus tendon tears in misdiagnosis, lateral foot pain after ankle twist together with synovitis and fluid in the peroneal sheath should raise the suspicion of a tear. Failure to treat hindfoot varus deformity might result in a retear. Same situation might occur if ankle or tendon instability is left unaddressed or peroneal tubercle left unresected. During the operation a good exposure is helpful in detecting all the lesions. However, according to Steel and DeOrio only 40 % of their patients returned at the same level of sports after surgery.

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Ankle sprain – a simple and a benign injury?

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Turku University Hospital

Lateral ankle ligament injuries are prolific, but not always benign. In the United States more than one million individuals suffer severe ankle ligament trauma each year. (1). There the amount of ankle sprains per day is 23 000 (2). In the Netherlands, about 520 000 persons annually have a traumatic injury of the ankle. The incidence of an ankle sprain per year is 12.8 per 1000 patients (2). In Finland ankle sprains are the commonest musculoskeletal injury with an incidence of 500 per day (3).

About half of the patients with a lateral ankle sprain receive medical services. 7–10% of the patients at the emergency departments seek for medical advice after an ankle sprain (4). Several reviews prefer conventional treatment as initial treatment strategy. Conventional treatment consists of early mobilization, early weight bearing as tolerated and an external support such as taping or brace. In Finland, patients with acute ankle sprains usually are treated at the primary care offices by the general physicians.

Most of the ankle sprains are dislocations to inversion of a plantar flexed forefoot and involve the lateral ligament complex (5). The anterior talofibular ligament (ATFL) is the weakest of the three lateral ligaments. It is involved in the majority of lateral ankle sprains (up to 85%). Combined ruptures of the anterior talofibular and the calcaneofibular ligament (CFL) are seen in 50–75% of the lateral sprains. The posterior talofibular ligament (PTFL) is usually only involved in frank dislocations of the ankle.

Ligamentous lesions in acute inversion sprain perhaps should not be seen in this limited vision. There are variations of the CFL. In 58% of the cases the CFL is reinforced by lateral talocalcaneal ligament (LTCL). In 42% the LTCL is absent and replaced by an anterior talocalcaneal ligament (ATCL). In these cases the CFL is even more significant to the stability of the subtalar joint .

Physical examination is sufficient for diagnosis of a lateral ankle sprain. The current golden standard for the diagnosis of a lateral ankle sprain is delayed physical examination and radiography according the Ottawa ankle rules for excluding a fracture and evaluating the ankle mortise.

Consequences of ankle sprains include syndesmotic injuries, medial ligament complex involvement and tendon or osseous injuries. As magnetic resonance imaging is not routinely applied for the evaluation or an acute lateral ankle sprain, data on the prevalence of additional findings is sparse. There are no prospective studies to describe the frequencies of lateral ligament damage based in an acute ankle sprain to evaluate the risk of associated injuries.

Ankle sprains are thought to be benign injuries and to have a good prognosis (3), but still residual symptoms and recurrence are common (3). Up to 54% of individuals suffer recurrence of the ankle sprain with residual impairments (6).The most common residual impairments are re-sprain, perceived instability, giving way, joint laxity, pain, swelling, weakness and reduced level of physical activity. These alone or in combination are termed chronic ankle instability, CAI. 40 % of the patients have symptoms more than six months after the initial injury (6).

There are several studies of the clinical course of the injuries of the acute ankle sprains (6). However, the factors contributing to persistent symptoms are largely unknown. Risk factors for chronic instability may be cavovarus foot, limited ankle joint dorsiflexion range of movement, sports activity at high level (7) and severity of initial sprain. Pain-related fear of movement, or kinesiophobia, has also been shown to contribute to disability in F&A patients. Decreasing fear of movement seems to predict improvement of functioning (8).

A consensus statement is presented on the diagnosis and treatment of acute lateral ligament ruptures. Although treatment of an acute ankle sprain aims at recovery, it does not seem to lower the risk of re-injury. The use of proprioceptive training program after usual care of an ankle sprain is effective for prevention of self-reported recurrences. Bracing is found to be the dominant secondary preventive intervention of a re-sprain. The aim of prevention is to act so as something not happens. When a sprain has already occurred identification of relevant subgroups of patients with either better or worse prognosis is essential.

The relationship with chronic ankle instability and arthritis of the ankle joint has become obvious. The most common cause of end-stage osteoarthritis of the ankle is previous trauma (9-10). The talus may tilt, with progressive joint load, into varus or valgus, depending on the load pattern resulting from deformity of incompetence of ligament structures (11).

Cochraine Database review by Kerkhoffs et al 2002 indicates that patients with either acute lateral ligament tears or chronic mechanical ankle instability are best managed with bracing and rehabilitation program. However, after a functional treatment protocol 32 % of the patients reported chronic pain, swelling or recurrent sprains seven years post-injury. Up to 33% of the patients report pain after one year (6). Though it seems, that prevention of re-sprain by bracing or neuromuscular training does not necessary mean as a self-reported good result.

Movement and motor control impairments are known to present secondary to the presence of pain (12). Motor control impairment and movement impairment are the two distinctive subgroups among the chronic foot and ankle disorders (13). A new model for classification of chronic foot and ankle disorders has been proposed. This new method is based on identifying the underlying mechanisms of the foot and ankle disorder within the bio-psychosocial framework.

In these two impairments the patient´s mal-adaptive behavior is the underlying mechanism for the foot and ankle pain. In motor control impairments lack of motor control drives the pain (14). On the foot and ankle region the symptoms are related to the loading pattern. In movement impairments loss of normal physiological movement drives the pain. Pain avoidance is characteristic (14). Often, motor control and movement impairments appear as loss of variable movements of the forefoot and hindfoot (13).

Evaluating prognostic factors for poor recovery would make it possible to determine which patients are at risk for non-recovery. Current clinical practice guidelines offer few recommendations on possible prognostic factors associated with an acute lateral ankle sprain. Determining important prognostic markers will provide higher level of evidence for clinical decision making and help identify the patients which are at high risk for residual complains.

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Large osteochondral fractures in patellar dislocation

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Patellar dislocation is the most common major knee trauma in pediatric and adolescent population. Despite high redislocation and chondral injury rate, common consensus (among experts) favors non-surgical treatment for this injury, except in acute patellar dislocation with large osteochondral fracture (OCF). What is the evidence-base for this guideline? My narrative review of the literature shows that little is known about the natural course of cartilage lesions or healing of OCF and evidence on operative treatment consists of only case reports or small case series. I will briefly review my own experience of eight operatively treated OCFs retrieved from the patient database of Central Finland Central Hospital during the past four years. MRI imaging carried out 6 months postoperatively showed osseous healing in all OFCs, but cartilage deterioration was also found (in most of the cases), especially if the injury was in the patellar surface.

Introduction

Acute patellar dislocation is the second most common cause for acute knee hemarthrosis and the most common pediatric and adolescent knee trauma (1). Treatment for acute patellar dislocation remains somewhat controversial, but common consensus favors conservative treatment despite relatively high (30–70 %) recurrence rate and evidence that ultimately, patients with a patellar dislocation develop chondral damage in 25–100 % of patients, depending on classification (2–6). OCFs are relatively common finding in acute patellar dislocation, from 24 % up to 72 % of cases (2, 3, 5). Operative treatment is restricted to cases with large OCFs (4, 5).

OCF associated with patellar dislocation are typically seen in the inferomedial part of the patella or the lateral femoral condyle. OCF can vary from small marginal avulsions of the medial patellar facet to large weight carrying surface fractures with varying amount of bone attached to cartilage (7). No proper literature is found on epidemiology of large OCF in acute patellar dislocation in pediatric population, but they occur in approximately 10–15 % of acute dislocations (4). Most of these OCF (80–90 %) can be visualized in plain x-rays, but MRI indisputably offers a more reliable tool to evaluate the lesion in terms of the size, location and quality as well as the accompanied, other soft tissue injuries (7, 8).

Similarly to many other orthopedic complaints, one of the major challenges regarding OCFs is that we have no validated classification for the characterization of the injury. Somewhat discouragingly - and likely at least partly due to absence of uniformly accepted classification, the existing consensus simply states that operative treatment should be carried out in patients with OCF "large enough" to be fixed (4, 5). In this narrative review of the literature, I will briefly review the existing evidence and my own experience on the treatment of OCFs associated with acute patellar dislocation.

Patients

Eight cases with the diagnosis codes S83.0 and S83.3 (patellar dislocation and acute chondral damage) and the operative code NGF35 (re-attachment of OCF) and a six-month clinical and MRI follow-up were found from the patient database of Central Finland Central Hospital. Patients were 11–16 years of age with open or just closed epiphyseal plates. Upon presentation at the ER, all of them had a hemarthrosis and seeked for care during the day of trauma. In every patient OCF was seen in X-ray. MRI was also done within the first week after injury and operative treatment within 6–17 days from trauma. Four patients had OCF of the patella and four that of the femoral condyle. The size of the OCF fragment, as determined from the MRI, ranged from 15 x 15 mm to 21 x 26 mm. The amount of bone attached to the cartilage also varied: most often, there was only a sliver of bone or merely subchondral lamina. In each case, a diagnostic arthroscopy was carried out first, followed by open fixation of OCF through either medial or lateral arthrotomy. Most of the loose fragments were found to be fixed in synovium. In all patients, the OCF fragment was too large to fit the avulsion site, and accordingly, both the avulsed fragment and the bone avulsion site were trimmed to ensure optimal fit. All fragments were fixed with polyglycolic pins and cartilage was sutured with 6-0 coated vicryl. MPFL reconstruction was carried out in five cases: in two patients with open physis, the adductor magnus tenodesis was used and in three cases with closed physis, reconstruction with the graclis tendon was carried out. In the remaining three cases, the chosen procedure was MPFL "re-insertion".

Postoperative full range of movement was encouraged. Partial weight bearing was advised for 4–6 weeks, followed by a progressive rehabilitation including walking, cycling, swimming etc. Running and pivoting sports were avoided for 4–6 months depending on the progress of rehabilitation.

Results

MRI was carried out in each case approximately 6 months postoperative. All fractures were considered 'healed'. In every patellar OCF (n=4), the cartilage was found to be abnormal, irregularly shaped with high signal intensity and chondral thinning. Lateral femoral condyle fractures (n=4) showed better healing: three were classified as normal, while one patient had irregularity and minor signs of cartilage thinning.

In clinical examination, all except one patient was deemed well healed: all had full range of movement, and almost asymptomatic knee. However, one patient had experienced episodes of subluxation and a single dislocation. He also had the smallest (15 x 15mm) OCF lesion in the lateral condyle, which was not perfectly healed in MRI. He underwent MPFL

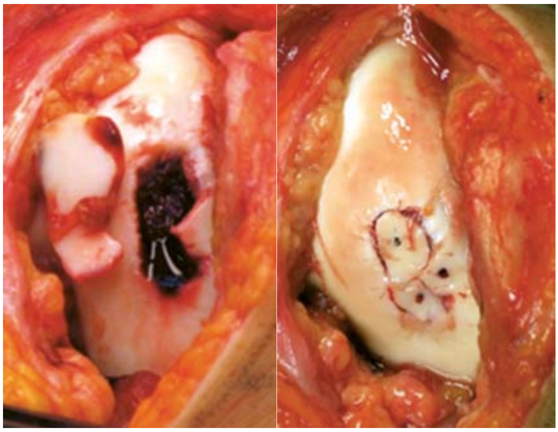

Figure 1. Fourteen year old boy, lateral femoral condyle OCF. Trimmed and fixed with polyglycolic pins and 6-0 Vicryl sutures.

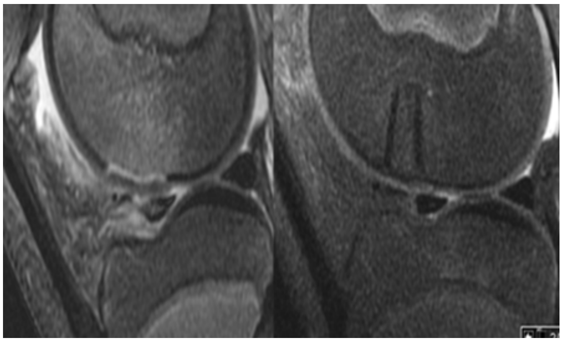

Figure 2. Same boy as in picture one. Left MRI after dislocation and OCF, which is best seen as abcence of subchondral plate . On the right same area 6 months post-sugery, where subchondral plate is restored and cartilage seems normal.

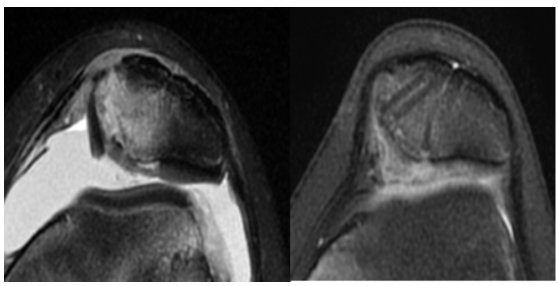

Figure 3. 12 year old girl with patellar OCF and MRI 12 months postoperative. Cartilage is irregular, nonhomogenous and has high intensity signal.

reconstruction with gracilis tendon two years after index operation, in which MPFL "re-insertion" had been done.

Discussion

This retrospective case-series of eight consecutive patients is, to my knowledge, the largest MRI follow-up study on operatively-treated OCF in patellar dislocation to date. This study showed that operatively-treated OCF following patellar dislocation possesses excellent capacity to gain at least osseus healing, even with minimal amount of bone attached to cartilage, but on the other hand cartilage deterioration of OCF was seen especially on patellar side.

The fact that all patients were treated by the same operative and post-operative protocol and all had MRI done 6 months post-operative to evaluate healing of OCF can be considered as the strengths of this case-series. There are, however, serious weaknesses, too. Namely, the retrospective nature of the study, the absence of validated patient-reported outcome measures and the limited number of patients. In this context, there is also an obvious risk of bias related to non-blinding: the fact that the same surgeon who carried out all the operations also carried out the follow-up. Finally, it needs to be noted that the follow-up time was too short to obtain information on redislocations or long-term outcome of OCF.

Notwithstanding these obvious weaknesses, the sample size of this paper compares favourably with previous studies. Walsh & al. published one of the largest studies on OCFs in which they reported five-year follow-up of eight femoral lateral condyle OCFs (9). These patients had twisting injuries of knee, no patellar dislocations. All cases underwent open surgery and fixing of OCF with polyglycolic pins. At five-year follow-up, three patients reported their knee as excellent as assessed by the Cincinnati knee rating system, while three were rated as good and two as fair. All OCFs had healed in MRI but cartilage thinning and irregularity was seen in five cases and one patient had abnormal appearance of whole OCF area. Only two were considered normal.

French multicenter study reported results of 14 OCF after acute patellar dislocation (10). Nine OCFs involved the lateral femoral condyle and five the patella, all underwent ORIF. Fractures were fixed with screws, resorbable pins or pullout sutured. Two patients had additional Goldwaith procedure. The authors reported that at 30-month follow-up, all fractures were healed, but only five patients underwent postoperative MRI. IKDC score was A in eight patients, B in five and C in one. No OCFs had to undergo revision surgery, but three patients underwent patellar-stabilizing surgery during the follow-up period.

To date, the largest series on patellar OCFs after acute patellar dislocation includes nine patients (11). Four of the patients underwent ORIF (average size of the lesion: 3,2 cm2) and in five, the lesion was simply excised (average size of the lesion: 1,2 cm2) and the avulsion site was treated with microfractures. In a 30-month follow-up, there were two redislocations in both groups. One fixation failed, resulting in subsequent removal of the loose body. Another patient in the ORIF group needed operative treatment for arthrofibrosis. KOOS and IKDC scores were higher in the non-fixation group.

Orthopedic surgeons seem to have a very uniform general consensus that cartilage damage is associated with substantial functional harm. However, as evident from this narrative review, solid evidence on the key issues related to cartilage damage are poorly documented and there is a virtual absence of high-quality evidence on the existing rationale for the treatment of these injuries. We have abundance of evidence – both experimental and clinical – to suggest that cartilage injuries where subchondral bone is violated lead to fibrocartilage healing. We also know that tissue quality of fibrocartilage is not equivalent to native hyaline cartilage. Some retrospective case series have shown that patients with cartilage injuries have a relatively good prognosis (4, 12, 13, 14). However, a number of other reports suggest that less serious cartilage injuries progress and cause cartilage degeneration after patellar dislocation (2, 15). To coarsely summarize the existing tenet: the larger the area and the greater the involvement of the weight bearing surface, the more likely it is to result in local and generalized cartilage deterioration (16, 17). Various cartilage restoring methods (such as microfracture or chondrocyte implantation) have been shown to result in different qualities of fibrocartilage, but not good quality hyaline cartilage (18, 19). Thus, it seems logical to try to restore large OCF of weight carrying surfaces and save cartilage reconstruction methods for revision cases.

Summary

Both natural and operative history of OCF is poorly documented. Rationale to fix OCF is to preserve own hyaline cartilage. Unfortunately, the existing – albeit, of relatively poor quality – evidence seems to show that cartilage of OCF lesion undergoes deterioration by time thus ruining the effort of trying to preserve hyaline cartilage. Guidance of operative treatment on OCF in patellar dislocations seems to derive from expert opinion rather than scientific evidence. I am tempted to propose that we should explore the possibility that OCF lesions would either be left in place (if asymptomatic) and only those loose bodies causing symptoms would be removed, as we have compelling evidence to suggest that acute patellar dislocations can be treated conservatively. However, one can also argue that the reported good short term results and low complication rates advocate the prevailing rationale of fixing the OCF. More rigorous study design with longer follow-up and larger patient groups are needed to ultimately show both the fate of OCF cartilage and the possible benefits of surgery.

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Open ankle fractures: Current treatment

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Open ankle fractures are rare injuries with a high incidence of wound complications and infection related morbidity. Many of the patients with an open ankle fracture are elderly people, and with an ageing population the number of open ankle fractures is likely to increase. Most open ankle injuries are Weber type B fractures with a medial-sided wound, and immediate internal fixation can be performed in the majority of the patients. Younger patients are more prone to suffer an open ankle fracture with high-energy injury mechanism and more severe soft-tissue injury, leading to more complicated outcome. The historical "six-hour open fracture rule" has very little support in the available literature, and day-time trauma theaters may be the most efficacious way to deal with most open ankle fractures.

Introduction

Open ankle fractures are among of the most severe injuries of the ankle. These fractures are rare injuries with a reported incidence of only 4.5% of all ankle fractures (1). Open ankle fractures often require multiple surgical procedures, and have a high likelihood of wound complications and subsequent infections (1). Open ankle fractures are traditionally considered as high-energy injuries in young active patients (2–4). However, a recent study showed that many of the patients with an open ankle fracture are actually elderly women, who sustain an open ankle fracture resulting from a same level fall (1). The incidence of open ankle fractures is increasing (1), which is not surprising since the number of active elderly people sustaining a complicated ankle fracture is increasing (5,6).

Antibiotic therapy and soft-tissue management

In the treatment of open fractures, the objectives are to prevent deep infection, promote fracture consolidation, and restore function while minimizing complications (7). Effective antibiotic therapy, thorough debridement, careful tissue handling techniques, stabilization of the fracture, and coverage of the wound are of paramount importance (7,8). The timing of antibiotic therapy plays a very important role. The rate of infection increases when antibiotics are commenced more than three hours after the injury, thus first or second generation cephalosporins should be administered in the emergency room (ER) without delay (3). Wound swabs should not be taken in the ER since initial cultures do not represent the microbes that eventually may cause the deep infection (3). The optimal duration of antibiotic treatment is not known.

The goals of soft-tissue management in open fractures include debridement of all devitalized material and restoration of a viable soft-tissue envelope to provide a stable environment for bone healing (8). In the ER, all gross debris and contamination should be removed, and fracture-dislocations should be reduced immediately. After irrigation, the wound is covered with sterile dressings and the fracture is temporarily stabilized with a splint. In the operating theater, the wound has to be carefully debrided. In view of the poor soft-tissue coverage around the ankle, the preservation of skin viability plays a significant role in successful management of open ankle fractures (2). Most wounds are lacerations on the medial side of the ankle

(1). These wounds often result from skin that is lacerated by the sharp edge of medially displaced tibia, such that most of the wound edge is viable and should not be resected (2). After meticulous debridement, irrigation must be carried out again. Irrigation of the wound is very important as it serves to decrease bacterial load and to remove foreign bodies (3). High-pressure pulsatile lavage is most effective for the removal of bacteria and other contaminants (3,9,10). However, high-pressure pulsatile lavage may have deleterious effects including bone damage and increased depth of bacterial penetration, thus irrigation must be carried out with caution (1,3,9,10).

Timing of operative treatment

Traditional guidelines suggest treatment of open fractures with initial operative debridement within six-hours after the injury to reduce the risk of infection (11). However, recent studies have questioned the association between delayed surgical treatment and the development of a deep infection in open injuries (11–13). Studies have shown that postoperative complications seem to be related with the type of initial soft-tissue injury and postoperative malreduction rather than with delayed operative treatment (3,14). Many open ankle fractures present outside normal hospital working hours (1), and some authors have suggested an increased risk of complications associated with after-hours surgery (15). In the treatment of open ankle fractures, postponing surgery should be minimized whenever possible, and all patients should be operated within the first 24 hours (3). Especially, non-reducible fracture-dislocations and Gustilo grade III injuries should be operated without delay as emergency surgery (Figure 1). However, given the low number of deep infections in less severe Gustilo grade I-II open ankle fractures (13), day-time trauma theaters may be the most efficacious way to deal with most open ankle fractures (1).

Immediate or delayed internal fixation?

In open ankle fractures, poor functional outcome is associated with inability to achieve anatomical reduction, loss of reduction, and development of deep infection (3). Immediate fixation of open fractures has many beneficial effects, including protection of soft-tissues from additional trauma from unstable fracture fragments, improved tissue healing, promotion of early mobilization, and reduction of infection risk (3,16). In open ankle fractures, immediate open reduction and internal fixation (ORIF) is safe and leads to good functional outcome (3). Additionally, immediate ORIF leads to shorter hospital stay and less stiffness when compared to delayed fixation (3). In a systematic literature review of open ankle fractures, 81% of patients had satisfactory results following immediate ORIF (3). Only in grade III injuries, and when there is inadequate soft-tissue to cover the osteosynthesis material, external fixation should be considered for temporary fixation (3).

Timing of wound closure

Despite many advances in wound care, debate remains regarding the utility of primary wound closure compared with delayed wound closure (8). Until recently, no clinical guidelines or protocols have been available to determine which wounds are amenable to prima-

Figure 1. A severe Gustilo grade IIIB open ankle fracture-dislocation with a 12cm medial-sided wound in a 66-year-old obese woman following a same level fall. In the ER, antibiotic therapy was initiated without delay and the wound was irrigated. However, fracture could not be reduced by closed means, and surgical debridement with ORIF was performed as emergency. The wound was left open and NPWT was initiated. The wound was secondarily closed with sutures after infection had been ruled out.

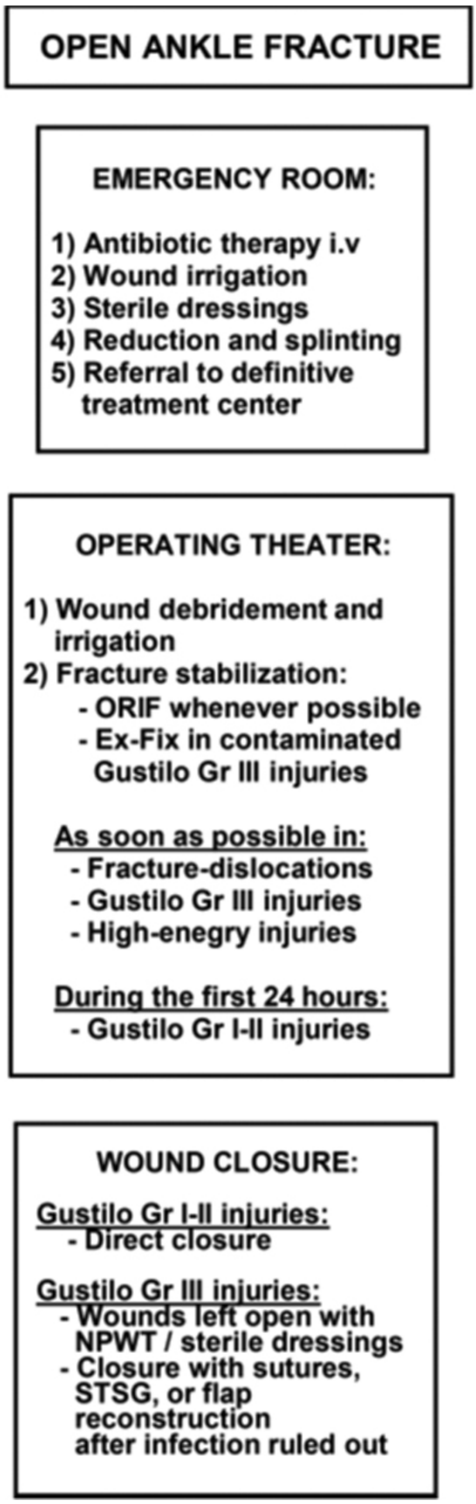

Figure 2. A proposed treatment path for open ankle fractures.

ry closure (3). In a recent study with 131 open ankle fractures, 80% of the wounds were primarily closed. Although nearly one fifth of those patients developed wound necrosis (1), only 5% eventually required flap reconstruction for wound coverage. In contrast, 30% of those patients in whom wounds were primarily left open required flap reconstruction to cover the soft-tissue defect. Altogether, flap reconstruction was required in 10% of patients with open ankle fractures (1).

A systematic review on open ankle fractures recommends that grade I and II wounds may be closed primarily when the wound can be closed without significant tension (3). Grade III open ankle injuries should be left open and managed with skin grafts of flap reconstruction after infection has been ruled out (3,8). Some authors recommend that primary wound closure should probably be considered only if the initial injury is a result of a low-energy trauma mechanism (8).

Deep infection and other complications

An open fracture is a known risk factor for wound complications (12,17,18), and the rate of deep infection increases with higher Gustilo grades (3,7,8,11,13). The prevalence of infection following internal fixation of fractures is 5% overall, but may exceed 30% in open fractures (19). In the literature of open ankle fractures, the incidence of deep infection ranges from 8% even up to 17% (1,3). Deep infection leads to poor functional outcomes and should be avoided by early administration of antibiotics, debridement, irrigation, and preserving viable soft-tissues in the fracture site (3,14).

Complications are very common in open ankle fractures (1). According to the published literature, every other patient may have a complication following an open ankle injury (1). The most common complications are wound necrosis (14–18%), deep infection (8–17%), postoperative malreduction or loss of reduction (17%), and severe TC-arthritis (11%) (1,3). Lower extremity amputation rate of 2% has been reported in patients with open ankle fractures (1).

Open ankle fractures in the elderly

Open ankle fractures are conventionally considered as high-energy injuries in young active patients (2–4). However, in a recent study the mean age of patients with open ankle fractures was 60 years, and nearly 40% of the patients were over 65 years of age (1). More than half of the patients were women, and only one fifth of the fractures were the result of high-energy trauma (1). In that study, high-energy injuries were more common in younger patients. These patients also had more lateral-sided open wounds than older patients. Younger patients had significantly more complications, suffered more often from chronic pain, and required more flap reconstructions, reoperations, and outpatient clinic visits (1).

Conclusion

Effective antibiotic therapy, meticulous debridement, stabilization of the fracture, and coverage of the wound are of paramount importance when treating open ankle fractures. A proposed treatment path is presented in Figure 2. Many patients with an open ankle fracture are elderly people. However, injury mechanism appears to be more important than patient age in predicting the outcome of these injuries. Younger patients are more prone to suffer an open ankle fracture with high-energy injury mechanism and more severe soft-tissue injury, leading to more complicated outcome. The historical “six-hour open fracture rule” has very little support in the available literature, and day-time trauma theaters may be the most efficacious way to deal with most open ankle fractures.

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Thoracolumbar fractures in the Elderly

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Majority of spine fractures in elderly population are related to osteoporosis and low injury energy. Conservative treatment is preferred in most cases. Persistent back pain and neurogenic pain are the reasons to consider operative treatment when proper conservative treatment has failed. Segmental instability or deformity, stenosis of spinal canal with spinal cord or nerve root compression or intolerable loss of sagittal balance are the typical problems that may address poorly to conservative treatment and require surgical approach. History of trauma is very important since aging population has also high or moderate energy trauma and they should be treated with same principles as young patients. Unlike typical young high-energy trauma patients, elderly population has comorbidities, variable bone quality and other underlying skeletal degenerative changes, which must be taken into consideration when operative treatment of thoracolumbar fracture is planned.

Introduction

Fracture of the spinal column is the most typical osteoporotic fracture. They can be divided to acute or chronic fractures. Chronic fractures are typically multiple simultaneous changes in very osteoporotic spine and lead to significant kyphosis of the spine. A single fracture with low trauma energy can be the first manifestation of clinically significant loss of bone mineral density (BMD) or osteoporosis. Dual energy X-ray absorptiometry (DEXA) is used to evaluate BMD but it's clinical usefulness is poor if the patient is short, with small bones, low BMI and has high age, the range of over- or underestimation can be as high as 20–50% (1). Antiresorptive bisphosphonates are introduced as medical solution for treatment and prevention of osteoporotic fractures. Their effect on preventing osteoporotic spine fractures in very high age is very controversial and cost-effectiveness and compliancy of medication use is poor (2,3,4).

Majority of the spine fractures are anterior column fractures, endplate changes or wedging compression fractures and stable as such. Poor quality of life is associated to pain and progressing kyphosis, which may in the end cause problems with ventilation function and malnutrition due to skeletal compression of upper abdomen (5). The incidence of fractures in elderly population is growing (6) rapidly after 60 years of age (Figure 1). Some fracture types appear typically in elderly population. Thoracolumbar fractures are typical in elderly female population whereas cervical fractures appear in similar pattern in both genders. Good social conditions and medical treatment lead to increasing amount of fractures in elderly population, and growing need for expensive and complicated treatment of these fractures. The best prevention of spine fractures is to avoid falling, improve balance and physical activity and decrease smoking and undernourishment in elderly population.

Indications for operative treatment in elderly population are generally the same as in younger patients, but wider range of contraindications and risks have to be considered.

Special features and conservative treatment have been recently discussed in this journal (5) and thus this article emphasizes the operative treatment.

Conservative treatment

Conservative treatment with medication, bracing and percutaneous injections is golden standard in stable fractures and the method of choice when comorbidities and extensivity of operative choices prevent surgery. Both vertebroplasty (VP)- and kyphoplasty (KP) are equally efficient in treating acute pain and disability. Neither VP nor KP have long-term effect or capability of preventing instability or deformity (7,8,9) or are cost-effective and capable of improving mortality or major medical outcomes (10). Injection of PMMA cement or tricalcic phosphate may be a good method for treating acute pain, which does not respond to adequate medication or side effects of drugs prevail. Very morbid or demented patients may not tolerate percutaneous cement augmentation treatment since they require capability of lying still in prone position during the treatment and imaging. Although mini-invasive, cement injections can have minor or major complications. Cement leakage can lead to vascular and pulmonary embolism or cord and nerve root injury, which may require immediate surgical intervention. To avoid thermal irritation of neural elements PMMA cement can be replaced with injectable tricalcic phosphate. Adjacent vertebral fracture risk after vertebroplasty is 21% (range 2–50%) and high if patient has low BMI and BMD and intradiscal cement leakage in previous vertebroplasty (11). Some authors suggest that kyphoplasty could be safer due to less cement leakage. Higher cement viscosity, lower injection pressure and limited cavity created by balloon explain the difference in cement distribution.

Preoperative evaluation

Fracture morphology

Thoracolumbar fracture classifications can be utilized in all ages. AO, Denis, Load Sharing classification (Figure 2) or TLICS/TLISS can be applied. Young patients seldom sustain spontaneous or low energy spine fractures, but in aging population the mechanism of trauma is even more important to recollect. Stability of bony and ligament structures have to be estimated after high or moderate energy trauma. Stiff and degenerated spine may sustain fractures of specific morphology (12). Adequate imaging is essential. In borderline cases, mobilization, observation and reconsideration of treatment modality is a good option, but such elderly patients must not be lost from surgeons controls, while benign osteoporotic fractures can be treated in basic health care.

Strong indicators for operative treatment are high TLISS points with injury of all columns and posterior ligament complex or posttraumatic compromise of spinal canal and severe neurologic symptoms. Also progressing kyphosis with local pain and possible in-

Table 1. Targets of operative treatment of spinal fractures

Surgical targets
Stabilization of the unstable fracture Prevention of neurological injury (progression) Correction of local deformity Correction of global alignment of spine

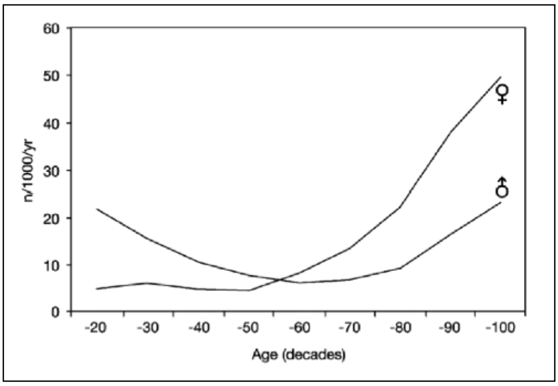

Figure 1. Overall fracture age and gender distribution curves by Court-Brown et al 2006 (6).

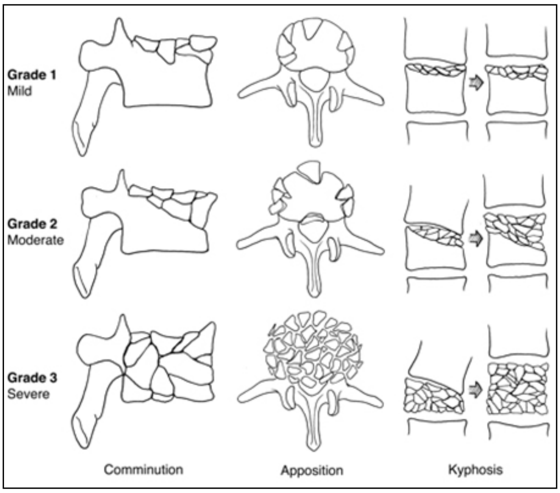

Figure 2. Load Sharing classification for comminution and anterior column stability of thoracolumbar fracture.

stability and significant symptomatic loss of sagittal balance indicate considering benefit of operative correction and stabilization (Figure 3). Fracture and deformity morphology give the minimum requirements for operative solution. Patient-related features define additional requirements for fracture surgery.

Bone quality

Normal values of bone mineral density (BMD) decrease with age. Osteoporosis or –penia are frequent findings in elderly predominantly female population. Previous history of typical fracture manifestations of osteoporosis is important. In acute situations, DEXA may not be available and its pitfalls (1) recognized. Nutritional, endocrinologic and medication history can give suspicion of other bone morbidities, for example osteomalacia and low levels of vitamin-D or other bone dystrophies.

Comorbidities

In aging population biologic and numeric age can be very different. Still, high age has to be taken seriously even the patient is in very good condition and appears to be younger than date of birth indicates. Consulting an anesthetist for ASA classification and perioperative risks is essential. Full medical history and also spesific spine-related history have to be evaluated. Patient may have had also previous spine surgery and fusions with or without instrumentation, or may have AS, DISH, severe spondylarthrosis or degenerative deformity (12). Possibility of pathologic fracture has to be considered and treated as a combination of oncologic therapy. Obesity, high age, undernourishment, diabetes mellitus, smoking and other chronic medical conditions increase risk of postoperative complications. Also general anaesthesia is associated with increased mortality, incidence of thromboembolism, myocardial infarction, bleeding complications, pneumonia, delirium, respiratory failure, and renal failure compared to regional anaesthesia (13).

Surgical techniques and planning

Standard procedure of one segment fracture is short segment instrumentation. In fracture material of young people there has been no evidence that spondylodesis and acquired posterior fusion improves outcomes or prevents slowly progressing posttraumatic kyphosis. In comminuted fractures, anterior column support is recommended. In elderly patients, where bone quality, neuromuscular control of the trunk and degenerative ankylosing and stenosing processes compromise the optimal method of choice, analysis of the spine has to be wider than only the immediate peri-fracture anatomy.

In acute B- or C-type unstable fractures stabilization and anatomic correction of kyphosis is essential. Overcorrection of generally kyphotic spine using the acute fracture as an osteotomy is not recommended. The need for anterior support or long instrumentation is to be considered when poor bone quality and screw grip are known. Load sharing classification can be helpful when deciding on need for anterior support

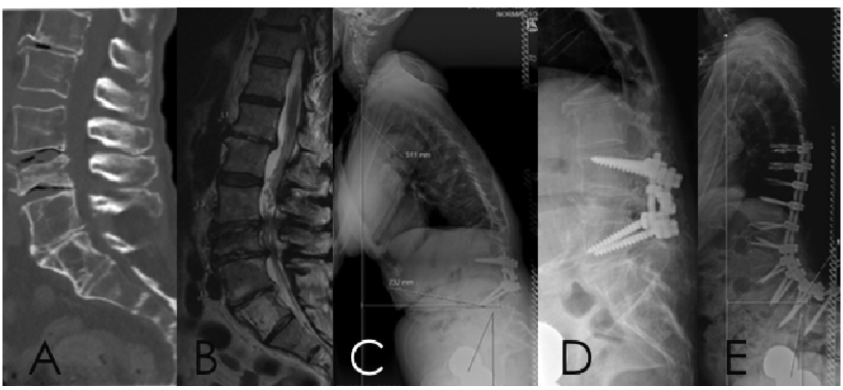

Figure 3. 72y female patient with primary low energy fracture in L3 (A) and spinal stenosis (B). Secondary low energy fracture in Th12 and severe loss of sagittal balance (C). Instability of the kyphotic segment and mobility of thoracic spine tested with bending and fulcrum x-rays (D). Stabilization of kyphotic fracture, correction with pedicle subtraction osteotomy in primary upper instrumented level L2 and mounting the long construction to pelvis with iliac screws (E).

– the more comminution, the more anterior support and multiple fixation points are needed. Very poor bone quality places a challenge to all anterior grafting.

The classic spinal fracture reduction- and fixation systems that are most useful and developed to be used in young patients may not provide the best purchase of elderly spine. Instrument constructions used in deformity surgery have many benefits also in elderly patients fracture treatment. Combination of anterior and posterior approaches has more perioperative complications than posterior approach only, which may limit optimal approaches in comorbid patients (14). Interbody grafting can be carried out with autologous iliac crest, costa or allogenic bone graft, or with PEEK (polyaryletheretherketone), titanium and other synthetic cages (15). In osteoporotic spine fractures, the adequate anterior column support can often be more safely achieved with instrumented fusion and fracture augmentation with vertebro- or kyphoplasty cement (16,17,18).

Typical problems are poor screw purchase and pullout, proximal or distal junctional kyphosis and failure of the construct. Attempts to control them include augmenting fixation points and the fractured vertebra with PMMA cement or tricalcic phosphate. Augmentation can be done via cannulated implant, which has higher pullout force than augmenting the vertebra and then applying the screw. The clinical threshold of adequate grip is reached with both methods. Tricalcic phosphate cement gives lower pullout grip than PMMA cement, but it has own benefits as being resorbable without thermal application effect. Cement augmentation has become most used augmentation method in osteoporotic bone, but also bi-cortical, expanding and double screws can be used (15,19,20). When a pedicle screw loses its grip to bone, replacing it with a larger screw does not add purchase to the bone. If a screw canal grip is lost, it is recommended to augment the salvage screw instead of leaving a larger screw (21).

Positive global sagittal balance of the elderly, the kyphosis of the fracture and poor bone quality are all risk factors for failing the proximal fixation. The failure can be cranial or caudal, but the most common post-instrumentation failure is in the proximal junction. Kyphosis is common above instrumentation, but failure of the kyphotic segment requiring revision surgery is uncommon in degenerative spine surgery. There are several attempts to control severe, symptomatic proximal junctional failure in deformity surgery and the same methods can be applied also in fracture surgery. The term soft landing has been introduced in trying to control bone failure. Transverse process hooks have been used as the topmost anchor but there seems to be no proper impact on proximal failure (22). Constructions of sublaminar wires or bands attached to vertical rods in different configurations have been tried with varying success. Now the most promising method appears to be combination of soft or hybrid rods, which are more flexible from the proximal end, cement augmenting of the topmost two to four pedicle screws and a prophylactic vertebroplasty to the lowest uninstrumented proximal vertebra. It is also important to fix long constructions over the kyphotic curve and not to stop instrumentation in the apex of coronal or sagittal deformity. The importance of reaching good sagittal alignment is essential in avoiding postoperative mechanical complications. Good sagittal balance is also associated with good postoperative patient reported outcome (23).

Novel ideas of medical support for surgery have been reported. Off-label use of teriparatide, the only anabolic osteoporosis medication, has been shown to improve bone formation and prevent implant-bone failure (15). Some animal models have been published on local or even systemic use of BMP´s (bone morphogenetic proteins) with observation of better fusion and bone formation (24). These discoveries need further research to be proven safe and effective.

Complications

Complications of spine surgery can be divided to immediate perioperative problems, medical and implant-bone-related problems. Risk of major complications or even death is highest if patient has ASA class four or more, or spine surgery is due to trauma, tumour or infection. Pulmonary embolism, deep infection and cardiorespiratory problems are most common of major complications.

Prevention of complications starts from preoperative planning and optimizing aged and comorbid patients as well as possible. In chronic fractures there is more time for wider examinations and for example optimizing bone quality. Patient positioning, perioperative care and meticulous anaesthetic treatment are key issues in preventing severe complications. Elderly patients do not tolerate well major blood loss, perioperative hypovolemia, -tension or –termia. Aged patient with a fracture, either traumatic or malignant, are at highest risk of thromboembolism. They also may have obligatory anticoagulation due to cardiovascular events or treatments and surgical team has to balance between bleeding and thromboembolism. North American Spine Society and American College of Chest Physicians have announced evidence based guidelines to apply low molecular weight heparins or foot pumps (pneumatic sequential compression devices) to control these risks. In risk patients either of them, LMWH or foot pumps, and in high-risk patients with multiple trauma, malignant disease or hypercoagulable state both of them are recommended perioperatively.

Conclusion

It is important to differentiate acute and chronic, stable and unstable spine fractures in elderly patients. Wrong treatment choices and progression of the osteoporotic deformity can lead to multiple complications and poor outcome. It is also crucial to differentiate those patients who benefit operative treatment and restoration of global balance (Figure 3).

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Surgical Timing in Polytrauma Patients - an orthopaedic perspective

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The timing of treatment of orthopaedic injuries in multiply injured patients has undergone major changes in the last century. The timing of definitive fracture management has varied from several weeks to within hours of injury. In the last decades many studies identified a clear benefit from early definitive care of long bone fractures, a principle known as early total care (ETC). The most seriously injured patients, however, were shown to benefit from damage control orthopaedics (DCO), an approach employing primary external fixator stabilization followed by secondary intramedullary nailing. Debate over the relative pros and cons of these approaches with enhanced understanding of biological response to injury has led to recent emphasis on the need for aggressive patient monitoring and continued multidisciplinary evaluation of the patient's physiological response to treatment. Particularly in the volatile situation of a hemodynamically unstable polytrauma patient with changing priorities, this continuous evaluation is critical in determining the optimal treatment strategy.

Polytrauma patients are defined as patients with injuries to more than one body part that alone or in combination are life threatening. The treatment of these patients is aimed at saving life and limb with the goal of maximizing functional recovery. Treatment is initiated in the field by emergency medical personnel and continued in the emergency department utilizing the ATLS (advanced trauma life support) approach. Emergent management focuses on evaluation, resuscitation, and stabilization by addressing immediately life threatening injuries and bleeding. Achieving hemostasis is imperative to prevent the trauma triad of death (acidosis, coagulopathy, hypothermia) from spiraling to the patient's demise.

In achieving the best possible outcome for our polytrauma patients, a multidisciplinary team approach is necessary. These patients typically sustain several long bone fractures, which largely influence their ability to regain their pre-morbid functional level. Femoral shaft fractures are commonly used as a reference point to standardize or represent the vast multiplicity of injury patterns suffered by polytrauma patients.

Historical overview

From an orthopaedic perspective great changes in the treatment principles have evolved over the last century. Prior to the world wars polytraumatized patients were considered too ill to be managed operatively and even fracture manipulation was not recommended for fear of fat embolisation (1). This led to mal-union problems, which were addressed with the institution of various forms of traction. Long hospital stays with immobilization in bed resulted in pneumonia, bed sores, and pulmonary embolism (2). During the First World War, the introduction of the Thomas splint brought a 60% reduction in mortality to femoral fractures caused by gunshot. This highlighted the importance of early fracture stabilization and renewed interest in operative management was furthered by surgical advances.

Debate about the optimal timing of fracture fixation only arose in the 1960s when Smith recommended fixation to be delayed two weeks post-injury as early fixation showed increased rates of non-union(3) . Other authors showed greater mortality rates for patients undergoing surgery within two weeks of injury (4). These recommendations perpetuated long hospital and intensive care stays which still carried risks of pneumonia, bed sores, joint stiffness, muscle atrophy and psychological sequelae (5). The first to dispute this management principle was Riska et al from Töölö Hospital, who in 1977 showed that early fracture fixation (within two weeks) was protective from these complications and most importantly improved mortality (6). During the 1970s advances in intensive care and surgical implants also led to improved patient outcomes.

During the 1980s, retrospective studies on adult respiratory distress syndrome showed that early operative fixation reduced mortality and the risk of FES as well as ARDS particularly in the most severely injured patients (7–9). The first prospective study carried out by Bone et al showed that femoral fracture patients operated within 24 hours spent less time in intensive care and carried a smaller risk of ARDS or pneumonia than similar patients treated after 48 hour of injury (10). Other studies of the time showed polytrauma patients' general condition deteriorate in the first days following injury, due to impaired lung function and worsening nutritional status (11). These studies led to a paradigm shift which saw the average time to fracture fixation reduced from about 9 days to less than two or even within 24 hours in some centers (12). This new principle became known as Early Total Care (ETC) with all orthopaedic injuries definitively managed at an early stage. ETC reduced mortality, the need for ICU and ventilator support, the incidence of ARDS, sepsis, multiple organ failure, fracture complications and the need for hospital care as well as overall treatment costs (13).

In the 1990's, however, overly exuberant application of the ETC principle led to even minor orthopaedic injuries being treated operatively within 24 hours. This in turn resulted in increased operative time and blood loss with poorer functional outcomes (6). As a result emphasis on the severity of injuries became topical as Pape et al showed that polytrauma patients with femoral fractures and chest injuries had a greater risk of ARDS if fracture fixation took place within 24 hours (33%) compared to patients treated beyond the first 24 hour (7.7%) (14). On the other, hand patients without chest trauma were protected from pulmonary complications if threated early within 24 hours. Other studies supported this finding that the most severely injured patients suffered from the ETC principle and so the concept of the Borderline patient arose (15–16). Explanation for why some patients suffered from early treatment while others benefited was sought from biological processes.

Biological basis

Significant injury causes a systemic metabolic reaction in the patient through the central nervous system acting via the neuroendocrine system to release epinephrine to limit blood loss and preserve vital organ functions. This physiological response happens in unison with a sub-cellular inflammatory reaction. Tissue damage releases local pro-inflammatory (IL-1, -6, -8 and TNF-alpha) and anti- inflammatory (IL-4, -10, -11 and TGF) cytokines within the injured tissue. With sufficient injury, these cytokines spill into systemic circulation setting up a systemic inflammatory response with the prior leading to a pro-inflammatory systemic inflammatory response (SIR) and the latter a counter-regulatory anti-inflammatory response (CAR) (17). Loss of the precarious balance between these pro- and anti-inflammatory responses in turn leads to their respective syndromes. SIRS (SIR syndrome) can result in multiple organ failure and death, while CARS (CAR syndrome) can lead to immunosuppression, sepsis and death.

Greater understanding of these biological processes brought about the hit theory. According to this theory, the patient's homeostasis is delivered a destabilizing hit when subjected to an injury. If this hit is severe enough, the patient can develop SIRS or ARDS directly as a result of injury. Resuscitative treatment, however, aims at returning the patient to normal physiology and homeostasis. Any further injury, in the form of surgical intervention, represents a second hit to the patient and can result in further harm. Operative intervention at a precarious stage of recovery can tip the patient into SIRS or CARS resulting in ARDS, multiple organ dysfunction syndrome (MODS), multiple organ failure (MOF), sepsis or even death. This theory explained the differences identified in clinical studies and paved the way for a new treatment principal called damage control surgery (18).

Damage control surgery

The concept of damage control surgery (DCS) was first introduced by Rotondo et al in dealing with the most severely injured abdominal trauma patients (19). The aim was simply to do the bare minimum necessary to stabilize the patient accepting that further definitive surgery was necessary if the patient survived. Scalea at al applied this principle to orthopaedics by recommending a two step approach with quick primary external fixation followed by secondary definitive fixation once this was most opportune from the patient's physiological perspective (20). This approach minimizes the inflammatory impact (second hit) of the initial intervention while achieving the benefits of early fracture stabilization while allowing the more invasive definitive treatment to be performed under optimized conditions (21).

Proponents of ETC criticized the two step approach for potentially increasing the risk of infection. Studies into the optimal timing of the definitive intervention have leaned on the evidence of a bi-modal inflammatory reaction following injury. During the first day the SIR builds up, which begins to settle by the fourth day. This is followed by the developing immunosuppressed CAR phase, which begins to have clinical significance by around day 10. This leaves a window of opportunity when conversion to definitive fixation can take place under optimized inflammatory conditions (22). Operative stress during the peaks of SIR and CAR phases on the other hand would maximize the second hit effect and thus be detrimental to the patient's recovery (table 1).

ETC and DCO how to choose

The DCO principle, like in abdominal trauma, should only be applied to the most severely injured and, thus, efforts to identify those who benefited were pursued. Various parameters have been used such as systolic blood pressure, body temperature, platelet count, serum lactate, Base excess, lung function, urine output and a variety of injury scores. Inflammatory blood markers like IL-6, IL-10 and CRP have also been studied, but not gained favor. Utilizing these parameters and applying clinical experience, authors started dividing patients into four categories (23):

Stable:	Clinically and hemodynamically stable
Borderline:	Hemodynamic instability with slight shock and tissue hypoxia
Unstable:	Hemodynamic instability with severe shock and tissue hypoxia
In Extremis:	Imminently life-threatening condition

These categories represent a continuum of patient physiology and injury characteristics, but they provide crude divisions so as to allow development of treatment algorithms (table 2). Stable polytrauma patients can and should be treated with ETC. Borderline and possibly even unstable patients who respond well to resuscitative efforts (responders) can be considered for ETC given continued close monitoring of their physiological condition. Any deterioration (transient responders) should lead to a change of approach to DCO. Patients without significant improvement despite resuscitative efforts (non-responders) should be treated by DCO. In extremis patients represent the most critically ill and often their orthopaedic injuries are of secondary importance to the immediately life threatening chest or abdominal injuries and so should have all their injuries treated in order under damage control principles.

Adapted from Bone 2011

Polytrauma patients represent a heterogeneous group of patients with a variety of injuries of varying severity. In literature, femoral fractures have been used to standardize these patients, but also the effect of specific associated injuries has been explored. Particularly, the role of head injuries and the timing of extensive orthopaedic surgery has been a worry.

Polytrauma patients suffer with an associated head injury in 20 % of cases and this is a major cause of

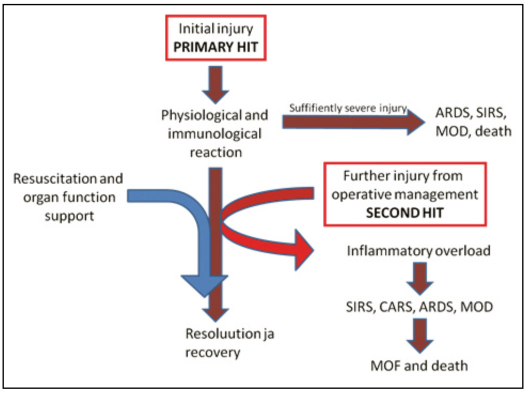

Table 1.

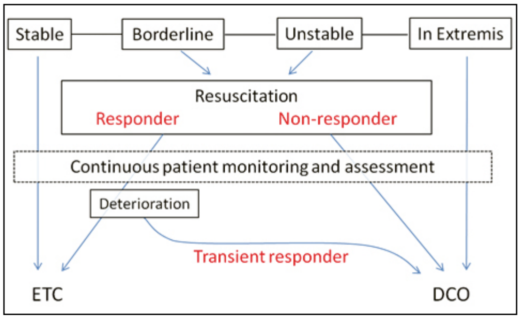

Table 2.

mortality and the primary determinant of final functional recovery. Preventing secondary brain injury is at the forefront of treatment. Several studies have shown cerebral perfusion pressure to decrease while intracranial pressure has risen during intramedullary nailing of long bone fractures (24). This is compounded by intraoperative blood loss and resultant coagulopathy, leading to reduced cerebral oxygenation and, thus, may represent a second insult to the injured brain (25). On the other hand, some studies failed to show a detrimental effect from early operative fixation while others found the primary brain injury to be the main determinant of recovery.

Significant chest trauma also plays a role in the timing of orthopaedic fixation. Injuries such as rib fractures, pulmonary contusion, pneumothorax and or hemothorax interfere with ventilation and raise the risk of pneumonia and ARDS. Early definitive orthopaedic fixation has been shown to further raise the risk of ARDS as compared to delayed fixation. Other studies, however, have failed to show this relationship (26).

In recent years, three large systematic reviews have looked at the current evidence regarding the optimal time of definitive orthopaedic fixation in polytrauma patients (27-29). These publications failed to identify superiority of one approach over the other, with no statistically significant difference identified in mortality, complications, effect of chest trauma or brain injury. The major drawback in comparing the primary studies was the significant variation in definition of early versus late, ranging from 8 hours to two weeks.

Due to a lack of conclusive evidence of which patients benefit from the DCO approach, emphasis has shifted to the assessment of the patient's physiological status (30). Continuous judicious monitoring of the patient's clinical and physiological parameters during initial resuscitation and early operative care, guide decision making in these volatile patients. These parameters include, blood pressure, body temperature, urine output, oxygenation, lactate and coagulation time. Early detection of deterioration is imperative, allowing adjustment of treatment priorities and shifting from ETC to DCO.

Greater understanding of the basic science and clinical experience has led to better appreciation of the continuum of polytrauma patients with no clear cutoffs or definition for dividing patients into one treatment arm or the other. Decision making requires vigilance and constant monitoring by the whole trauma team coupled with effective communication, particularly between surgeons and anaesthetists. Identifying and evaluating treatment priorities and altering them as necessary is key to success in these dynamic and precarious situations. Deciding between ETC and DCO alone is not relevant, but rather understanding the patient's complete situation (response to resuscitation and injury complex) so as to provide them the best possible care.

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Acromioclavicular joint dislocation – current treatment

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What is generally accepted is that type I and II AC joint dislocations may be treated nonoperatively (1-3). Even in most athletes, nonoperative treatment leads to a successful outcome (4). As in other clavicle injuries, the arm is immobilized with a sling for 2 to 3 weeks following gradual mobilization. Mouhsine et al. (5) discovered that the severity of consequences after type I and II injuries is underestimated, since one-third of the patients complained of activity-related pain or had residual AP instability after nonoperative treatment.

The management of type III dislocations is controversial. Nonoperative treatment is proposed because it includes good functional results, a short period of rehabilitation, and a low complication rate (6,7). Nonoperative and operative treatment modalities comparing studies on type III dislocations report uniform results, such as a shorter rehabilitation period and better restoration of shoulder movement after nonoperative treatment, similar functional results in both groups, and more complications in the operative group (8-10). Nonoperative treatment does not restore joint anatomy, and a sense of instability may remain, but still long-term results are good (11).

In the literature insufficient scientific evidence exists to assess results of nonoperative treatment in type IV, V, or VI dislocation. Nevertheless, constant joint dislocation leads to a general consensus in favor of surgery for these injuries. Mulier et al. (12) found that type IV and V injuries had poorer results after nonoperative treatment than did type III injuries. Some studies report sequelae, such as shoulder pain, AC joint instability, and impaired shoulder function after nonoperative treatment of type V injury, and thus prefer surgery (13-16).

The literature regarding surgery in AC joint injuries is generally limited to retrospective case series of small heterogeneous samples and thus has a low level of evidence. Only four prospective level II studies comparing operative to nonoperative treatment have been published (8-10,17). Although simple in concept, more than 70 surgical procedures have been described to treat AC joint injuries, but none is yet established as the gold standard (18). The abundance of surgical procedures described makes it difficult to discern the best technique or approach to handle AC joint separation. The timing of surgery and type of reconstruction needed in any particular injury is unsolved. To clarify the issue, the surgical options can be divided into (1) AC joint fixation with pins, screws, suture wires, and plates, (2) coracoacromial (CA) ligament transfer, (3) CC interval fixation, and (4) ligament reconstruction. Each of these techniques has numerous modifications and combinations and of course inherent complications.

Early surgical techniques involved temporary AC joint fixation with Kirschner wires, pins, or screws all crossing the AC joint. At present, these are more or less unpopular due to their high complication rate, including migration and the loss of reduction (19-21). Despite poor reputation of Kirschner wire fixation, it has been widely used, and not all the results are poor. In acute type III injuries, temporary Kirschner wire fixation has achieved good long-term results for shoulder function (22,23). Another widely used method is temporary AC joint stabilization with a hook plate. Advantages of the hook plate are stable fixation maintaining the AC joint biomechanics and thus allowing early postoperative mobilization (24). One retrospective study of 23 patients found good functional results after a 30-month follow-up, although in 35% of patients, after plate removal loss of reduction occurred (25). Di Francesco et al. (26) performed MRI one year after hook plate removal in a cohort of 42 patients with type III or V injuries. The MRI showed CC ligament healing with continuous scar tissue in 88%. In the remaining patients, healing occurred with non-continuous scar tissue, and the manifestation was recurrence of joint dislocation. Use of the hook plate is criticized because it may overcorrect the AC joint, it requires removal (a second operation), it may induce osteolysis in or erosion of the acromion, or cause subacromial impingement. Another danger is risk of fracture of the acromion or the clavicle (24,27-31).

Weaver and Dunn first published a case series of 15 patients treated with CA ligament transfer. In their technique, 1.5- to 2-cm resection of the lateral clavicle is performed, and after clavicle resetting, the CA ligament is transferred from the acromion to the lateral end of the clavicle to replace torn CC ligaments (32). Since then, numerous modifications of this ligament-transferring procedure have appeared, and it has also been combined with various other methods. Sood et al. (33) published a literature review covering all studies discussing CA ligament transfer in AC joint dislocations. They found that all published studies were low-level case series (level IV evidence) with variability in surgical techniques and outcome measures. They discovered low-level evidence to support the use of CA ligament transfer in AC joint dislocations, but this was associated with a high rate of dislocation recurrence. Adjunct fixation did not improve clinical results when compared to simple CA ligament transfer. Biomechanical studies have shown inferior characteristics of the CA ligament compared to those of the native AC joint (34,35).

Coracoclavicular interval fixation has involved screws, wires, sutures, endobuttons, and suture anchors. The commonality in these techniques is that they transfer the combined forces that the AC joint complex and CC ligaments are normally exposed to fixation points on the clavicle and coracoid process (18). Rigid screw fixation thorough the clavicle into the base of the coracoid process was first described by Bosworth (36). It is biomechanically too rigid and may lead to hardware failure, screw pullout, and osteolysis or fracture of the clavicle or coracoid process (18,37). Recently, studies have evaluated the use of absorbable and nonabsorbable sutures, endobuttons, and suture anchors. No clear difference emerges in usability or superiority between these methods, but they all prove superior to Weaver-Dunn reconstruction (34,38-41).

Anatomic AC and CC ligament reconstruction techniques have become popular. Among the various autograft or allograft tendons used are semitendinosus, gracilis, palmaris longus, peroneus brevis, or tibialis anterior. Clinical and biomechanical studies have shown their superiority in reproducing the strength and stiffness of the native AC joint complex compared with other techniques, and also in resulting in a good outcome in shoulder function (34,42-45). Reconstruction of both the CC and AC ligaments has shown beneficial effects upon AC joint stability (46,47). The complication rate is almost 30% in anatomic CC ligament reconstruction. Typical complications include tunnel malposition, graft ruptures, clavicle fractures, and hardware failures (48,49).

Arthroscopy-assisted or fully arthroscopic methods have also emerged to treat acute AC joint dislocation. They are used with various stabilizing devices and are suggested as minimizing morbidity and soft tissue damage. Thus far, studies discussing minimal invasive techniques are technical notes or retrospective case series with only small numbers of patients. It seems that the functional results are equal to those of open surgery (50-53).

Sometimes the surgery is performed after a long delay (several months) following unsuccessful nonoperative or operative treatment. A few preliminary studies report that in chronic AC joint dislocation, CC ligament reconstruction with tendon graft has resulted in reasonable shoulder function (54,55). A few studies have compared results of early and delayed surgery. After early surgery, these are clearly superior to results of late reconstruction. Shoulder function, pain, degree of AC joint reduction, number of complications, and patient satisfaction are inferior with the delayed surgery (13,16). In both of these studies, delayed surgery was performed by the modified Weaver-Dunn procedure. The CA ligament is certainly not as strong and suitable for CC ligament reconstruction as is a tendon graft.

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New trends in surgical treatment of chronic osteomyelitis

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Successful treatment of chronic osteomyelitis necessitates usually surgical debridement of necrotic and infected bone in addition to systemic and local antibacterial treatment. Traditional way and gold standard of osteomyelitis surgery has been two staged: first, debridement of the bone and filling the void by antibiotic loaded polymethylmetacrylate (PMMA) beads or cement spacer and secondly, after some weeks: removal of the beads and bone grafting. In order to avoid the second operation and also due to some other problems related to PMMA, antibacterial bone grafts or bone graft substitutes have been proposed for a single stage treatment of chronic osteomyelitis. Alongside antibiotic loaded calcium phosphate and calcium sulphate based products, also bioactive glass has been used successfully as an antibacterial bone graft substitute. Clinical and scientific evidence supporting clinical use of these biodegradable bone graft substitutes is growing, but so far the number of high quality comparative studies is scarce.

Introduction

Osteomyelitis is a bacterial infection of bone and may lead to bone destruction. Staphylococcus aureus remains the most commonly isolated pathogen. Gram-negative bacilli as Pseudomonas and anaerobic organisms are also frequently isolated (1).

In adults osteomyelitis is most often related to open fractures or to any surgical procedure affecting bone or its adjacent tissues. Traumatic or other contaminated wounds close by bone may also progress to deep infection and osteomyelitis. Host related factors, like malnutrition, alcoholism, smoking, and systemic diseases, such as diabetes or peripheral vascular disease, also contribute to susceptibility and persistence of osteomyelitis.

In acute osteomyelitis inflammation is followed by local edema, vascular thrombosis, bone infarction and osteolysis. Acute infection may progress to chronic phase with abscess and sequestrum formation. Reparative mechanisms build new bone resulting in thickening and deformation of the bone.

In areas of poor vascularity and dead bone, bacteria can multiply and form biofilms, which protect them against antibiotics and host´s immuno defense mechanisms. Poor local vascularity leads to insufficient penetration of antibiotics to infected bone and due to biofilm, the need for antibiotic concentration has to be 10–100 fold higher than normal in order to eliminate bacteria.

Due to the nature of the disease, it is clear that chronic osteomyelitis needs surgery alongside appropriate antibiotic treatment, which should be based on sensitivity studies of bone specimens taken directly from the infection focus. The traditional duration of antibiotic treatment in osteomyelitis is four to six weeks (1).

Surgical debridement

First and most important step of osteomyelitis surgery is radical debridement of all nonviable tissue, including soft tissue and bone. Debridement proceeds until bleeding viable tissue is seen at the resection margins indicating good vascularity (2). Usually contaminated implants have to be removed simultaneously. Specimens of purulent fluid, soft tissue, and bone from the affected area should be taken for microbiological diagnostics at the same time (3).

Management of bone defect

Successful treatment requires adequate management of dead space created by debridement. Otherwise the cavity is filled by hematoma, which is good environment for new bacterial growth and infection. Osseous reconstruction has traditionally involved a variety of techniques, including healing by secondary intention, closed irrigation and suction systems, temporary antibiotic-impregnated beads or spacer, autologous or allogenic bone grafts, free vascularized bone grafts and muscle flaps. During the last two decades several biodegradable bone graft substitutes have become more and more popular in clinical use (4, 5).

Antibiotic loaded bone cement

Antibiotic loaded polymethylmethacrylate (PMMA) has been used as local antibacterial bone void filler more than 30 years. In staged protocol, the cavity in the bone created by debridement is filled temporarily with antibiotic-impregnated PMMA beads or cement spacer. The beads are usually removed within two to four weeks and replaced with a cancellous bone graft. The antibiotics that are most commonly used in PMMA are vancomycin, tobramycin, and gentamicin. Local antibiotic therapy is a safe technique resulting in high local concentration of antibiotics with minimal systemic levels (6). Efficacy of gentamicin-PMMA in chronic osteomyelitis has been documented in several studies with success rate about 90% (7).

In addition to the necessity of the second operation, the use of PMMA is accompanied also by some other disadvantages. If prepared in situ, high temperatures can lead to thermal injury of the surrounding tissues. There are also some restrictions to incorporated antibiotics: they have to be heat-resistant and water-soluble. The implant itself can create bacterial resistance and a new biofilm infection if the antibiotic concentration drops over the course of time, and the PMMA implant acts as a foreign body (8, 9).

Biodegradable materials

An ideal bone graft should be osteoinductive, osteoconductive and have osteogenic properties. Also it should be structurally similar to bone, easy to use, cost effective and should integrate into the host tissue without graft versus host reactions. During the last ten years there has been a growing trend to search optimal antibacterial biodegradable bone graft substitutes as a part of surgical treatment of chronic osteomyelitis (4). Autologous bone graft still meets best criteria for optimal material but its availability, donor site morbidity and lacking inherent antibacterial properties restricts its clinical use in the treatment of osteomyelitis. Still bone grafts (autografts or allografts) have been used as a vehicle for local antibiotic delivery at least 30 years, but there is not clear consensus about optimal preparation and effective but safe antibiotic concentrations of these products (8).

Synthetic biodegradable polymers such as polylactide acid (PLA) and polylactic-co-glycolic acid (PLGA) have properties to work as antibiotic-impregnated graft delivery systems. Despite of promising results of in vitro and clinical studies, to date clear clinical applications do not exist (4).

Calcium sulphate and hydroxyapatite (i.e. calcium phosphate) and their combinations are traditional and well documented bone graft substitute materials. During the last ten years they have been used as antibiotic carriers in single stage treatment of chronic osteomyelitis (4). They are osteoconductive and have good biocompatibility and good resorption rates. In a recent study the use of tobramycin-loaded calcium sulphate carrier was examined in 195 patients for the treatment of chronic osteomyelitis in a single stage surgical protocol. After a mean follow-up time of 3,7 years 90,8% of treated patients were free of signs of infection (10).

Bioactive glasses (BAGs) are relatively new products for filling osteomyelitis related bone defects in a single stage protocol. Bioactive glass S53P4 (BonAlive, BonAlive Biomaterials Ltd, Finland) is a synthetic biocompatible osteoconductive bone substitute, with bone bonding capacity and documented antibacterial and angiogenesis-promoting properties (11–14). In 2011 it is approved as a medical device in Europe for the treatment of osteomyelitis. Antibacterial properties are related to an increase in the local pH and osmotic pressure. This material has a wide spectrum of bactericidal activity and it has also antibiofilm properties (15, 16). To date no induction of bacterial resistance has been reported to BAG-S53P4.

In a recent retrospective study BAG-S53P4 (n=27) was compared with two calcium based bone substitutes (hydroxyapatite + calcium sulphate compound, n=27 and tricalciumphosphate + antibiotic loaded demineralized bone matrix, n=22). After a mean follow-up time of 21,8 months 92,1% of the BAG-group showed no signs of infection. Infection eradication rates were comparable in all treatment groups but in calcium based groups there was more prolonged serous wound leakage (17).

In an ongoing retrospective multicenter study 102 patients with chronic osteomyelitis were treated with BAG-S53P4 granules, 85 of them in one-stage procedure. After a follow-up time of at least one year 90% of patients were considered to be free of infection. Prolonged seroma leakage was noticed in 3 patients (18).

Discussion

In contrast to acute osteomyelitis, successful treatment of chronic osteomyelitis is usually not possible with systemic antibiotics alone. Meticulous surgical debridement of all necrotic and infected bone is the cornerstone of the treatment. Obliteration of dead space by locally antibacterial material and adequate soft-tissue coverage ensure best possible results.

Traditional two-stage surgery with antibiotic loaded polymethylmetacrylate implants has been challenged seriously by several antibacterial biodegradable bone graft substitutes, which enable single stage surgery with cure rate about 90% in follow-up time of some years.

According to preliminary clinical and scientific evidence it seems that calcium sulphate and hydoxyapatite based bone graft substitutes and bioactive glass (BAG-S53P4) are in the front line in the one-stage treatment of osteomyelitis related bone defects. Their antibacterial efficacy has been comparable in clinical studies. Bioactive glass seems to have less seroma leakage problems and to date no induction of bacterial resistance has been reported. It has also angiogenic and biofilm destructing properties, which may have beneficial impact on wound healing.

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XVII Finnish-Austrian Orthopaedic Trauma Course

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Vesa Hamunen

Sunday, January 25, 2015

12.00 Registration

18.00 OPENING SEREMONY

18.00 Welcome
Jan Lindahl, MD
Chairman

18.10 Welcome to Oberlech
Patrick Ortlieb
Olympic gold medalist and World champion in Downhill skiing

18.20 Program details
Juha Kalske, MD

19.00 Dinner

Monday, January 26, 2015

08.00 SESSION I – Injuries around the knee
Chairmen: Jan Lindahl, MD and Axel Gänsslen, MD

08.00 Basic principles of the use of LCP in distal femoral fractures – How to avoid complications?
Axel Gänsslen, MD
Klinikum der Stadt Wolfsburg, Wolfsburg, Germany

08.20 MPFL reconstruction – Indications and surgical technique
Petri Sillanpää, MD
Tampere University Hospital, Tampere, Finland

08.40 Patella and quadriceps tendon ruptures
Thomas Ibounig, MD
Helsinki University Central Hospital, Helsinki, Finland

09.00 New approaches to the proximal tibia
Axel Gänsslen, MD
Klinikum der Stadt Wolfsburg, Wolfsburg, Germany

09.20 Wound complications after plate fixation of proximal tibia fractures
Markus Parkkinen, MD, Tatu Mäkinen, MD, Rami Madanat, MD, Jan Lindahl, MD
Helsinki University Central Hospital, Helsinki, Finland

09.40 Coffee and technical exhibition

10.00 SESSION II – Foot and ankle
Chairmen: Oliver Michelsson, MD and Wolfgang Greghenig, MD

10.00 Posterior approach to the ankle – Surgical anatomy and reduction techniques
Wolfgang Grechenig, MD, Prof.
Unfallkrankenhaus der AUVA, Graz, Austria

10.20 Osteotomies around the ankle
Annette Moser, MD
Kantonsspital Baselland, Liestal, Switzerland

10.40 Ankle sprain – A simple and benign injury?
Anne Flink, MD
Turku University Hospital, Turku, Finland

10.55 Treatment of sequelae after ankle and pilon fractures
Annette Moser, MD
Kantonsspital Baselland, Liestal, Switzerland

11.15 Future of arthrosopic arthrodesis of the ankle
Oliver Michelsson, MD
Hospital Diacor, Helsinki, Finland

11.35 Longitudinal peroneal tendon rupture- Aetiology and treatment
Jouni Heikkilä, MD
Hospital Mehiläinen, Turku, Finland

11.50 Discussion
Faculty

12.00 Lunch and technical exhibition

16.00 Discussion in groups (case presentations) I:
Group I: Knee injuries
Group II: Ankle
Group III: Arthroscopy

19.00 Dinner

Tuesday, January 27, 2015

08.00 SESSION III – Lower extremity
Chairmen: Juha Kalske, MD and Axel Gänsslen, MD

08.00 Revision ACL surgery
Jürgen Mandl, MD,
Unfallkrankenhaus der AUVA, Graz, Austria

08.20 Patellar dislocation and ostreochondral fracture
Heikki Nurmi, MD
Central Finland Central Hospital, Jyväskylä, Finland

08.40 Open ankle fractures - Current treatment
Mikko Ovaska, MD
Helsinki University Central Hospital, Helsinki, Finland

09.00 Hip Arthroscopy: Current Indications
Juha, Kalske, MD
HUCH, Jorvi Hospital, Espoo, Finland

09.20 Conservative approach to lateral hip pain
Matti Seppänen, MD
Turku University Hospital, Turku, Finland

09.40 How to reduce the risk of cardiovascular events in orthopedic surgery?
Marjatta Strandberg, MD
Turku University Hospital, Turku, Finland

09.55 Coffee and technical exhibition

10.15 AOTrauma symposium
Chairmen: Kati Kyrölä, MD and Axel Gänsslen, MD

10.15 Factors associated with outcome of spinopelvic dissociation treated with lumbopelvic fixation
Jan Lindahl, MD
Helsinki University Central Hospital, Helsinki, Finland

10.35 Pelvic fragility fractures
Iikka Lantto, MD
Oulu University Hospital, Oulu, Finland

10.55 Thoracolumbar fractures in the elderly
Kati Kyrölä, MD
Central Finland Central Hospital, Jyväskylä, Finland

11.15 Surgical timing in polytrauma patients—The orthopaedic perspective
Tomi Simons, MD
Helsinki University Central Hospital, Helsinki, Finland

11.35 Compartment syndrome of the lower leg – Diagnostics and treatment
Axel Gänsslen, MD
Klinikum der Stadt Wolfsburg, Wolfsburg, Germany

11.55 Sanofi Lunch Symposium - Treatment of knee osteoarthrosis
Chairmen: Wolfgang Grechenig, MD and Eero Hirvensalo, MD

11.55 New updated Finnish Guidelines for treatment of knee OA
Mikko Manninen, MD
ORTON Hospital, Helsinki, Finland

12.05 Viscosupplementation once a year - Synvisc One
Jari Markkanen
Sanofi

12.15 Discussion

13.00 Break and technical exhibition

16.00 Discussion in groups (Case presentations) II:
Group I: Ankle fractures
Group II: Lower extremity trauma

19.00 Dinner

Wednesday, January 28, 2015

08.00 SESSION V – Upper extremity
Chairmen: Timo Raatikainen, MD and Wolfgang Grechenig, MD

08.00 AC-dislocation – Current treatment
Kaisa Virtanen, MD
Helsinki University Central Hospital, Helsinki, Finland

08.20 Forearm - Surgical anatomy and exposures
Wolfgang Grechenig, MD, Prof.
Unfallkrankenhaus der AUVA, Graz, Austria

08.40 Capitulum radii fractures
Niko Strandberg, MD
Turku University Hospital, Turku, Finland

08.55 Distal radius – Volar and dorsal plating techniques
Wolfgang Grechenig, MD, Prof.
Unfallkrankenhaus der AUVA, Graz, Austria

09.15 Arthroscopically assisted fixation of intra-articular distal radius fractures
Jarkko Vasenius, MD
Oma sairaala, Helsinki, Finland

09.35 Coffee and technical exhibition

09.55 SESSION VI – Infection
Chairmen: Axel Gänsslen, MD and Mikko Manninen, MD

09.55 New trends in surgical treatment of chronic osteomyelitis
Vesa Juutilainen, MD
Helsinki University Central Hospital, Helsinki, Finland

10.15 The single stage osteomyelitis treatment process in Nuffield Orthopedic Centre, Oxford, UK
Martin McNally, MD
Oxford University Hospitals, Oxford, UK

10.35 A prospective clinical outcome study of a new biphasic absorbable composite carrier with gentamycin in the treatment of chronic osteomyelitis
Martin McNally, MD

Oxford University Hospitals, Oxford, United Kingdom

10.55 The single stage infection revision arthroplasty
Stefan Luck, MD,
Helios Endo-Klinik, Hamburg, Germany

11.25 The two staged infection revision arthroplasty
Mikko Manninen, MD
ORTON Hospital, Helsinki, Finland

11.45 “Round table” discussion
Faculty

11.55 Group picture

12.00 Lunch and technical exhibition

16.00 Discussion in groups (Case presentations) III:
Group I: Upper extremity Trauma
Group II: Infection

19.00 Dinner

Thursday, January 29, 2015

08.30 SESSION VII – Free papers – Upper extremity
Chairmen: Mikko Manninen, MD and Jan Lindahl, MD

09.45 Coffee and technical exhibition

10.15 SESSION X – Free papers – Lower extremity
Chairmen: Eero Hirvensalo, MD and Juha Kalske, MD

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..

Takakansi Copal