Managing traumatic joint lesions – indications and options for cartilage repair

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Lesions of cartilage surface and subchondral bone in synovial joints cause pain and functional impairment, and they hasten the progress of posttraumatic osteoarthritis. Several cartilage repair methods have been introduced for the repair of the osteochondral surface of the injured joint.

The surgical technique repertoire of our cartilage repair team consists of bone marrow stimulation techniques (microfractures, MF), autologous chondrocyte implantation (ACI), autologous osteochondral transfer (OAT) and cadaveric fresh osteochondral allografts (FOCA). Each method has its strengths and weaknesses.

New variations and enhancements of previous techniques are continuously developed. This has led to raising expenses. Benefits of new methods should be carefully evaluated.

Diagnosis

Traumatic joint surface injuries can develop after joint distorsion injuries and intra-articular fractures. In addition, developmental or acquired diseases can lead to joint damage. Large osteochondral lesions with a loss of the joint surface contour usually severely disturb the joint function and the causality between a trauma and an observed lesion is clear. In smaller lesions the clinical consequences can be more or less obscure. Small lesions can remain in quietness for periods of time before the onset of the symptoms. After some joint injuries the cartilage lesions develop gradually with a delay after the cell death caused by the impact.

Magnetic resonance imaging (MRI) is used for lesion evaluation and preoperative planning. The diagnosis for a recent traumatic lesion, osteochondritis dissecans (OCD) and osteonecrosis is usually clear. After time passes from the injury it can be challenging to differentiate between traumatic or degenerative lesions. A traumatic lesion is expected to be limited and no subchondral bone cysts should be present. It should be noted that an impact to the cartilage can cause chondrocyte death and the cartilage can degrade rapidly after a trauma even though the first MRI shows a survived cartilage and subchondral bone oedema.

Due to the delayed progression of the traumatic lesions and their symptoms, it is often a challenge to prove the causality between a previous trauma and an observed joint lesion.

In surgical decision making the observed size and morphology of the joint lesions determines the choice for surgical technique. Signs for osteoarthritis should be observed to evaluate the prognosis of the treatment. In some cases an arthroscopic evaluation is needed for the final decision of the best technique.

Indications

The period from the onset of symptoms before the development of posttraumatic osteoarthritis is the window for biological repair of a joint lesion. After posttraumatic osteoarthritis has developed the results of biological repair techniques are uncertain and usually biological reconstruction is not possible.

In young adults a biological reconstruction is always the first option. The goal is to restore the anatomy and function of the joint. A further goal is to slow down the progression of posttraumatic osteoarthritis.

Surgical techniques

If original tissue is available it is usually the best repair material available and an attempt to fix it is worthwhile. The outcome can be successful even if the fractured cartilage looks compromised and the diagnosis is delayed. A fractured full thickness cartilage - a flake fracture of the cartilage can be fixed with bioresorbable pins, fibrin glue and 6-0 resorbable sutures.

Bone marrow stimulation techniques were first used for the treatment of osteoarthritis as Pridie drillings. Later this technique evolved to microfractures. After a succesful repair a fibrocartilaginous tissue will fill the lesion area. The biomechanical properties and the durability are inferior to hyaline cartilage but in small lesions of less than 4 cm^2 this technique seems to work quite well. The ease of use, low expenses and good results make it a standard procedure to which other techniques are compared (1,2).

With an aim for more durable repair new methods have been developed. Autologous chondrocyte implantation can produce repair tissue resembling hyaline cartilage. We have used ACI if the lesion area is too large to be treated with microfractures or after a failed microfracture repair. When comparing ACI with MF to repair lesions of the same size there seems to be some advantages in the clinical outcome in favor for ACI but the differences are small (3–5).

Osteochondral lesions are challenging to treat. Microfractures are not suitable. A better option is the so-called sandwich technique, in which the bony defect is filled with autologous bone transplantation and ACI is used to repair the cartilage.

To some extent osteochondral plugs can be used as autologous transplants to repair joint lesions. Autologous osteochondral transfer is used mainly for osteochondral lesions but not for pure cartilage surface lesions. The donor site morbidity limits the repair size to approximately $2cm^2$ (6).

A cadaveric allograft is an alluring option because the size of the graft is not limited by donor site morbidity. The challenge is to transplant the graft so that the chondrocytes stay viable and the cartilage survives and integrates to the host joint. The graft should be stored in controlled conditions and not frozen. The transplantation should be done within five days. The use of FOCA technique requires an organized team and close collaboration with an organ transplantation center (7,8).

Osteochondral allograft transplantation was first used for join lesion repair in the beginning of the 1900-century. During the development of arthroplasty, the use and research of allografts were abandoned. Since the 1970's the method has gone through a renaissance. Fresh osteochondral allografts have been used for cartilage repair in specialised centers in Northern America. In Europe some cases have been treated in Rizzoli institute in Bologna. We have treated one patient in Helsinki University Central Hospital. Reports from the centers at Northern America show good long-term survivorship and clinical outcome (9).

New or enhanced techniques

Both bone marrow stimulation techniques and autologous cell implantation can be enhanced with the use of biomaterials. In autologous matrix induced chondrogenesis (AMIC) the lesion is prepared similarly as in microfractures and a collagen membrane is placed as a cover. It is suggested that microfractures with the collagen membrane shelter can be used for even larger lesions than microfractures alone (10).

In the ACI technique, the same synthetic collagen membrane has in most centers replaced the originally used periosteum as a cover for implanted chondrocyte suspension (ACI-C). Chondrocytes are known to lose their chondrogenic potential during repeated cell divisions. The chondrogenic potential has been linked to some cell properties and cell culture conditions. Therefore, new techniques have been developed with an aim to produce only the best chondrocytes for implantation (Characterized Chondrocyte Implantation, CCI) (11).

A variety of different biomaterial and cell-based techniques are under animal and clinical experiments. The research is mostly focused on improving chondro-

cyte implantation and bone marrow stimulation but also stem cell therapies are studied.

In the future, more options will be available for cartilage repair. Cell therapies are very strictly regulated by the legislation of European Union. Due to this, the manufacturing processes are more demanding and expenses of the cell therapies have raised. Development of novel biomaterials will raise the expenses even more.

Summary

The repair tissue matures very slowly and the integration of a transplanted graft takes its time. Therefore the patient should be well prepared for a long rehabilitation. It is recommended to consult a specialised team to offer the patient the right technique at the first operation. Well-organized teams and good clinical trials are needed to better understand the benefit of the new methods.

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