Histologic change of cartilage layer of osteochondritis dissecans before and after fixation in the knee

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Fixation of an osteochondral fragment to an osteochondral defect has often been performed in the treatment of patients with osteochondritis dissecans (OCD). However, the effect of this procedure remains controversial, because it is not clear whether the degenerated cartilage layer of the osteochondral fragment can be restored after fixation. Therefore, it is essential that the histological changes that occur in the osteochondral lesion of OCD after its fixation are well understood.

The purpose of this study was to evaluate the histologic changes of before and after internally fixed sites of the OCD lesion.

This study was reviewed and approved by the ethical committee of our university, and informed consent was obtained from all patients and their parents. A consecutive series of 20 patients (20 knees) with unstable lesions of OCD of the knee were treated with open reduction and internal fixation. There were 14 male patients and 6 females, with a mean age of 15 years (11 to 22). The procedure was performed either with bioabsorbable pins only, or with a combination of an autologous osteochondral plug and bioabsorbable pins. A needle biopsy was done at the time of fixation and the time of second-look arthroscopy at a mean of 7.8 months (6 to 9 months) after surgery.

At the final follow-up, all of the patients were satisfied with the results, and there was no swelling or limitation of range of motion in the operated knee. The Lysholm score improved from a mean preoperative score of 70.5 points to a mean of 98.3 at the final follow-up. MRI obtained at the second-look arthroscopy showed that the image intensity of the fixed fragment was similar to that of the surrounding normal articular cartilage. At the second-look arthroscopy, although the fragment was stable to probing and had an intact smooth surface, we could distinguish original OCD lesion from the normal surrounding tissue or osteochondral plug because the border was concave slightly. In general, the histology of the loose bodies at the time of fixation showed a marked tendency for the layered structure of normal cartilage to break down and for the extracellular matrix to be stained weakly by safranin O and immunohistological
staining for type II collagen. In regard to the biopsy specimens at the second-look arthroscopy, especially in the middle to deep layer, extracellular matrix was stained more densely than that of pre-fixation. In addition, the layered structure of cartilage apparently improved compared with that of pre-fixation.

Comparison of the biopsy samples obtained from lesions before and after fixation enabled us to confirm the improvement of histologic findings of fixed sites, leading to the conclusion that fixation of an osteochondral fragment to an osteochondral defect is effective to prevent the osteoarthritis, although a longer follow-up study is needed.
The cases of both joint cartilage lesions and osteoarthritis have been increasing in number. In the last year of current bone and joint decade, they have still been seen as major locomotor system problems affecting the human life unfavorably. In order to find novel and biological treatment methods for the reconstruction of the damaged articular surface, basic and applied investigations and surgical techniques have been still developing. Damage to articular cartilage can occur as a result of either traumatic mechanical destruction, or progressive mechanical degeneration (wear & tear). Because of its limited intrinsic healing capacity, articular cartilage cannot fully regenerate; thus, articular cartilage injuries eventually lead to secondary degenerative disease of the involved joint.

Among the diagnostic imaging modalities used, MRI has proven to be the most accurate having a sensitivity more than 95%. MRI is helpful to look for focal cartilage lesions as well as to look for loose bodies (pieces of cartilage that have detached and are floating in the knee) and additional pathology within the knee. However, the other standard for evaluation of articular cartilage lesions is arthroscopic assessment; The benefit afforded by direct visualization of the extent of the defect, enhances the surgeon’s capacity to precisely plan the appropriate treatment necessary to address the pathology by arthroscopy. Focal osteochondral and chondral lesions, osteoarthritis, osteochondritis dissecans could be evaluated arthroscopically but not subchondral area like MRI.

Widuchowski et al. reported that the patellar articular surface (36%) and the medial femoral condyle (34%) are the most frequent localizations of the cartilage lesions of the knee and according to Outerbridge classification grade II lesions (42%) are the most frequent grade of these cartilage lesions. Other injured sites are infrequently found on lateral tibia, lateral femoral condyle, trochlea or medial tibia. Curl et al
reviewed 31,516 knee arthroscopies and found that chondral injuries were reported in 63% of the cases. They reported 2.7 articular cartilage injuries per knee.
The increasing interest in the repair and regeneration of articular cartilage during the last 2-3 decades has initiated intense basic research and clinical development with promising results from all over the world. New treatment procedures have evolved like abrasionarthroplasty, microfracture, autologous osteochondral grafts or mosaicplasty and autologous chondrocyte transplantation or implantation. The subjective clinical results reported from most of these studies have had very few results of objective techniques to support the clinical outcomes. In basic research the results often differed between research laboratories and the results were not comparable due to different evaluation programs. In 1997 The International Cartilage Repair Society was founded and one of the first tasks addressed was to elaborate a research and clinical evaluation package to guide the researchers and clinicians in their scientific work.

There are two important areas to be discussed. First the pre treatment evaluation and second the post treatment evaluation.

PRE-TREATMENT DIAGNOSIS AND EVALUATION.

Pre treatment evaluation is focused on a correct diagnosis of the articular cartilage lesion and related background pathology. Adequate history and physical examination are the fundamentals for further diagnostic noninvasive and invasive investigations. Noninvasive MRI is an excellent tool for diagnosing and assessing articular cartilage lesions, location, grade (depth and size), containment and subchondral bone pathology or defect, meniscus and ligament injuries, synovial fluid and synovitis. Standing X-rays, hip-knee-ankle x-rays for evaluating joint space, osteophytes, malalignment and others. CT scan for patellar malalignment, instability and trochlear dysplasia etc. Invasive arthroscopy is the perfect tool for diagnosing and assessing cartilage lesions, meniscus and ligament injuries, synovitis and increased synovial fluid and other intraarticular pathology. It also allows adequate palpation and indentation stiffness test and biopsy when indicated.

The combined use of MRI and arthroscopy give most of the necessary information for an adequate diagnosis and indication. Related background pathology has to be diagnosed and addressed for the short and long term survival of the repair tissue.

POST-TREATMENT OBJECTIVE EVALUATION.

Noninvasive MRI has rapidly developed to become the best noninvasive technique to evaluate cartilage repair tissue both quantitatively and qualitatively. By using T1 weighted sequences for identifying glucosaminoglycans and T2 weighted sequences for identifying collagen type II and by adding intravenous or intraarticular gadolinium injections more information on the matrix composition and different concentrations of important components such as glucosaminoglycans (GAGs) is made possible. By following the repair tissue development over time
using d´GEMRIC (delayed Gadolinium Enhanced Magnetic Resonance Imaging of Cartilage) the concentration of GAGs can be measured. It may take 9-12 months before the GAGs concentration is normalized in the treated area and in thicker cartilage such as the patella it may take 15-24 month for complete normalization of the GAGs. This offers a great tool for assessing the tissue maturation and know when an athlete or worker can go back to sports and hard labour. Also complications can be diagnosed with MRI such as graft delaminations or hypertrophy and bone marrow edema.

Invasive technique such as arthroscopy is the outstanding tool for postoperative cartilage repair assessment and includes macroscopic tissue assessment by inspection and probing according to ICRS and allowing video pictures and video films of the repair area. Furthermore it gives possibilities for quantitative measurements of the stiffness by invasive indentation test of repair tissue in comparison with normal cartilage. It also allows biopsies from the repair area and surrounding normal cartilage for microscopic examination and immunohistochemical analysis of collagen types and GAGs (aggrecan and cartilage oligomeric matrix protein, COMP). For adequate histological examination a 2 mm diameter cylinder biopsy is taken perpendicular to the repair surface area and into the subchondral bone. For comparison a similar biopsy should be taken from normal cartilage in the joint. However, arthroscopy is an invasive procedure and especially combined with biopsies it is an increased risk for complications. In over 140 biopsies taken for analysis postoperatively, no complication was noted. It also is an ethical problem to jeopardize an excellent healing and result, just for scientific purposes.

Diagnostic Arthroscopic Assessment.

Since 1987 autologous chondrocyte implantation has been performed in Gothenburg, Sweden and a pilot study of 23 patients with a follow up of 36 months was published in 1994 (NEJM). From the experiences of this study we established the criteria for articular cartilage assessment including lesion location with a mapping system, sizing with measuring the longest diameter in mm and its longest perpendicular diameter of the intended excision of the lesion, the depth according to a 1-4 grades in the grade 4 including 4 A involvement of the subchondral bone plate and in grade 4 B involvement of the trabecular bone. Containment of the lesion was also registered as well as the condition of the opposing articular surface and other intraarticular pathology such as meniscus and ligament injuries (ACL, PCL). These criterias were included in the ICRS evaluation package in 1997.

Follow up Assessment.

Magnetic Resonance Imaging (MRI) has been used in the postoperative follow ups after ACI to assess defect filling, surface and matrix content using T1 weighted sequences for glucosaminoglycans and T2 for type II collagen as well as d´GEMRIC for measurements of GAGs concentration in the early as well as in long term follow ups (Minas 2001, Winalski 2003, Scheller et al 2002, Marlowitz et al 2004, Kiviranta –Vasara et al 2008, Vasiliadis-Peterson 2010). Scheller could demonstrate in ACI patients followed with d´GEMRIC from 3 to 24 months a gradual return of GAGs concentration to normal between 12-24 months. Kiviranta found a normalization after ACI at 9 months and on. Vasiliadis found a normal GAGs concentration in patients after ACI between 9-18½ years.
Arthroscopic follow up assessment.

In the NEJM article (1994) we used arthroscopy for macroscopic assessment by visualization and probing of repair tissue establishing a scoring scale including filling of defect 1-4 points, integration to surrounding cartilage 1-4 points and surface appearance 1-4 points. A total of maximum 12 points and this scoring system was also accepted by ICRS and included in the ICRS assessment package. The result of a 5-11 years follow up of 46 patients treated with ACI showed an average score of 10.6 out of maximal 12 points.

Arthroscopy also allows for videofilms and photos for analysis.

Arthroscopic indentation test was first used by Kiviranta et al in animal experiments and in evaluation of normal articular stiffness in the human knee using an arthroscopic indenter. First clinical evaluation of cartilage stiffness in repair tissue compared to normal cartilage was reported in AJSM by Peterson, Kiviranta et al. At the same time biopsies were taken for histology. The study showed that histology with hyaline-like cartilage repair tissue had the same indentation stiffness as normal surrounding cartilage. Fibrous repair tissue had a significant lower stiffness. Kiviranta reported an 80% return of stiffness in the repair area at 9 months after ACI.

Arthroscopic biopsy assessment.

In our follow ups after ACI we have examined over 140 biopsies. In the NEJM article 21 biopsies were taken from 23 patients in the early cases with a konkotome and later with a 2 mm diameter biopsy needle. In 15 cases with ACI on the femoral condyles 11 were assessed as hyaline-like repair tissue.

Immunohistochemical analysis were performed in 14 patients comparing biopsies taken from repair area and normal. Patients with histology of hyaline like repair tissue were assessed almost the same as normal cartilage content regarding Collagen type II and Aggrecan and Cartilage Oligomeric Matrix Protein (COMP).

Summary.

Arthroscopy is still the best tool for diagnosing and assessing articular cartilage lesions. Noninvasive MRI has a great potential for developing outstanding information in the future for adequate diagnosis.

In follow up studies arthroscopy with macroscopic assessment, indentation test and biopsies with histology and immunohistochemical analysis gives still most valuable information. However the development of MRI will soon give almost the same information being noninvasive and with less risks of complications.

Recommended reading.


Peterson L. Chondrocyte Transplantation, In Lippincott Williams & Wilkins: Master Techniques in Orthopaedic Surgery, Reconstructive Knee Surgery Editor Jackson D. Ch 24 pp 353-73