Original Research
Use of Autologous Grafts for Reconstruction of Osteochondral Defects of the Knee
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Abstract
This study reports on 13 patients (mean age: 31 years) with a femoral condyle defect >1.5 cm² who underwent treatment with an osteochondral graft of the same size obtained from the superior aspect of the lateral condyle, preserving the patellar groove. Mean follow-up was 61.5 months (range: 13-141 months). Twelve results were rated clinically as satisfactory with patients able to resume their normal pre-injury level of activity, and 1 case was rated as poor. No patient reported any patellar problems. Radiographic and computed tomographic evaluation demonstrated good integration of the graft in the host bone.

The results of this technique at relatively long-term follow-up are encouraging, with a high percentage of subjective satisfaction. This technique appears to be reliable and provides a valid solution for treatment of wide cartilage defects when other techniques are too complex or inadequate.

One of the most important problems in orthopedic surgery is reconstruction of damaged articular surface, especially in young patients. While total joint replacement is accepted for treatment of generalized joint diseases in patients >60 years old, alternative treatment procedures are preferable in younger patients with limited articular damage.

Identifying osteochondral defects from other pathologic joint surface alterations is important. Generalized joint diseases such as osteoarthritis or rheumatoid arthritis involve the entire articular surface including the bone, cartilage, and synovial tissue, while chondropathy is considered to be local articular cartilage alteration not associated with bone loss.

Damaged hyaline articular cartilage has a limited regeneration capacity. Exposed subchondral bone, when in contact with the articular environment, has no spontaneous healing capacity, and the progression in generalized articular diseases such as osteoarthritis is difficult to avoid.

Therefore, an osteochondral defect is defined as a full-thickness, localized loss of bone and cartilage tissue of the articular surface with no spontaneous healing capacity when located in the weight-bearing joint zone. This definition does not include childhood articular pathology. It is well-known that the skeletally immature knee has great healing ability. For this reason, the treatment of osteochondral knee defects in patients <15 years is usually conservative, with surgery reserved only for particular cases.

In adults, the etiology of an osteochondral defect can be difficult to establish. It can be considered as chondropathic evolution when the articular surface damage begins at the cartilage or as chronic microtraumatic etiology, but important bony substance loss rarely occurs.

After acute trauma, a fresh, nonreduced osteochondral fracture can evolve into an osteochondral defect, creating an articular incongruence. Typical juvenile disease such as osteochondritis dissecans is more likely to develop in older patients with loose or separated fragments and secondary large osteochon-
TABLE

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<th>Table: Comparison of postoperative results using various rating scales</th>
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Abbreviations: IKDC = International Knee Documentation Committee.
*The IKDC scale uses A, B, C, and D grades that correspond to excellent, good, fair, and poor results for the other rating scales.

Articular cartilage degeneration may be secondary to bone pathology. The bone disease that most frequently produces osteochondral defects in the knee is spontaneous or secondary osteonecrosis. Spontaneous osteonecrosis was first reported as a distinct clinicopathologic entity by Ahlbach et al in 1968 as a disease that affects the knee condyles and is prevalent in older patients, but it also occurs in relatively young people.4,5

Secondary osteonecrosis includes a broader range of clinical conditions in which such factors as steroid therapy, dysbarism, hemoglobinopathies, and metabolic disorders play a major role. Osteonecrosis is a pathologic entity that denotes local bone death. The overlying cartilage may remain healthy if not subjected to undue stresses. However, when the underlying bony support collapses, the cartilage degenerates, creating a large, full-thickness osteochondral defect. While the etiology of knee osteochondral defects differs, the important prognostic factors include patient age, severity of damage, and defect localization. When the defect is localized in a joint zone that undergoes continual stress, its progressive degeneration can lead to the destruction of the opposite articular side, thereby creating “kissing lesions.” Kissing lesions are the first step to monocompartmental osteoarthritis formation; therefore, diagnosis and treatment are important.

In young patients, large full-thickness osteochondral defects of the condylar weight-bearing surface require surgical reconstruction, preserving as much of the remaining healthy joint surface as possible. Restoration of the normal anatomy is likely to yield the best functional results, with the least risk of subsequent degenerative arthritis. However, surgery is necessary before secondary changes occur to the opposing joint surface.

This study evaluates the long-term results of a surgical technique for repairing osteochondral defects with autologous osteochondral grafts in young and middle-aged adult patients (range: 16-60 years).

MATERIALS AND METHODS

Patient Population. Thirteen patients with large femoral condylar osteochondral defects (5 osteonecrosis, 6 post-traumatic osteochondritis, and 2 osteochondritis dissecans) were treated with autologous osteochondral grafting. Mean patient age was 31 years (range: 16-52) at the time of surgery, and mean follow-up was 61.5 months (range: 13-141). The male:female ratio was 7:6.

Defects were located on the medial condyle in 11 cases, on the lateral condyle in 1 case, and on the lateral condyle associated with a tibial plate defect in 1 case. In all cases, the defect was 1-1.5 cm deep and 1.5-3 cm in diameter.

Surgical Technique. Surgery was performed with arthroscopic technique, positioning a tourniquet at the proximal part of the thigh. After the articular surface was exposed, the osteochondral defect was identified, and all fibrous tissue was excised down to a base of cancellous bone.

The depth of the graft site and the amount of bone resected was as large as necessary for bleeding bone to be reached on all sides of the defect. The osteochondral graft was removed from the donor zone on the superior aspect of the lateral femoral condyle, preserving the patellar groove. The graft bone was carefully contoured so that it fit precisely into the recipient bed, since graft fixation was accomplished by interference fit only.

The graft thickness was the same as the recipient site depth so that the graft cartilage surface did not sit either above or below the articular cartilage level of the femoral condyle. In four cases, sufficient graft stability was achieved with a press-fit fixation, while in nine cases, screw fixation was used. Screws were removed arthroscopically 1.5-2.5 months later before weight bearing was allowed.

Associated surgical procedures were performed in four cases (one tibial osteotomy, one femoral osteotomy, one arthroscopic meniscectomy and one patellar realignment). In one of these patients, a 39-year-old woman affected by post-tibial fracture osteochondritis with valgus knee deviation, the femoral osteotomy was associated with bipolar graft implantation (lateral femoral condyle and tibial plateau).

Postoperative Rehabilitation. Flexion was begun on the third postoperative day, and walking on two crutches and progressive weight bearing were started on the 45th postoperative day. Total weight bearing without crutches was allowed 60 days after surgery. This protocol due was not modified during the study period.

Patient Evaluation. Patients under-
went annual clinical and radiographic evaluations. For the clinical evaluation, the Lysholm, International Knee Documentation Committee (IKDC), Cincinnati, and Swedish rating scales were used.

Pre- and postoperative radiographs and postoperative CT scans were obtained. The degree of arthritis was determined using Ahlbac’s radiographic classification. Graft integration was evaluated using the CT scans.

RESULTS

Twelve out of thirteen patients were satisfied with their postoperative results. Twelve knees were rated as clinically excellent or good using the Lysholm, Swedish, and IKDC rating scales (Table). Eleven knees were rated as excellent or good and 1 as fair using the Cincinnati clinical grading scale. This slight discrepancy can be attributed to the fact that the Cincinnati scale puts stress on the sports activity of the patient. The 52-year old patient evaluated as a fair result using this scale did not perform any type of sport but fulfilled all normal everyday activities and was considered to be a good clinical result by other scales.

None of these 12 patients had a flexion deformity or extension lag, and none reported any patellar tracking disorders or anterior knee pain. Five patients reported mild swelling after vigorous activity.

The one poor result was obtained in a 39-year-old woman with post-tibial fracture osteochondritis and valgus knee deviation. She underwent a femoral osteotomy associated with bipolar graft implantation (lateral femoral condyle and tibial plateau). The grafts were fixed with screws, and after 2 months, the screws were removed arthroscopically, and knee mobilization was begun. At 31 months postoperative, the patient had a knee flexion deformity of 10°-15° and significant joint stiffness. At that time, the patient refused any further operative treatment or radiographic examination.

In patients who underwent arthroscopic screw removal, good graft integration was observed with no edge between the graft and surrounding cartilage. Graft cartilage was not collapsing or friable, suggesting good survival of the implant.

Standard radiographic and CT follow-up evaluation demonstrated good graft incorporation into the femur in 11 cases. Radiographic examination revealed an apparent graft prominence with joint space narrowing (Figs 1 and 2). This effect probably is created by the discrepancy of the articular cartilage depth in recipient and donor zones (the cartilage of the weight-bearing zone is deeper than that of the femoral condyle superior portion). When the transplant cartilage surface is positioned at the same level of the recipient zone articular surface, the prominence of the graft osseous component is perceptible radiographically.

Ahlback’s classification did not show any significant variation between preoperative and follow-up evaluation in 12 cases. The remaining case was not evaluated radiographically and was considered to be a poor result according to the clinical evaluation.

DISCUSSION

Numerous different techniques have been proposed for the treatment of osteochondral defects of the knee. The techniques can be divided into two principal groups: treatment without osteochondral defect reconstruction or treatment with defect reconstruction.

Osteochondritis zone evacuation and curettage of the remaining bone is one of the oldest techniques, especially for the treatment of osteochondritis dissecans. This technique became popular with the development of arthroscopy. However, it has now been demonstrated that this treatment is useful only for small defects as its use in other cases predisposes the patient to the development of osteoarthritis.

In 1964, Almgard and Wikstad reported on 50 young adult patients with osteochondritis dissecans who were treated with defect evacuation or loosened body extraction. The most rapid progression of osteoarthritis occurred in patients treated with defect evacuation. In a long-term study of 22 patients at 30 years of follow-up, Twyman et al found that if there is a large demuced bone area in a weight-bearing position, the long-term outlook is poor.
Drilling and debridement of osteochondral lesions produce a fresh blood supply, thereby stimulating new cartilage growth to cover the defect. This technique can be performed in arthroscopy, or arthroscopically or percutaneously, and is associated with curetage of the lesion zone.

Rae and Noble\(^7\) reported good results in 14 patients treated with arthroscopic drilling after short-term follow-up, but most authors\(^8,9\) believe that only small defects can be treated successfully by drilling. In larger lesions, the articular surface must be reconstructed.

Extra-articular drilling into the affected femoral condyle decreases intraosseous pressure and achieves core decompression. Some authors\(^10,11\) have reported good results with this procedure for the treatment of early stage knee osteonecrosis (ie, still radiographically invisible), but the same authors recognize the uselessness of this technique when flattening of the affected femoral condyle becomes apparent radiographically.

Proximal tibial osteotomy must be performed in knees with angular deformation. In cases in which the angular deformation is associated with an osteochondral defect, this procedure has been shown to be beneficial only if done in concomitance with defect grafting. Many authors report that tibial osteotomy alone is unable to prevent lesion collapse and encourage healing.\(^12-15\)

Most orthopedic surgeons agree that when a distal femur weight-bearing surface is affected by a large osteochondral defect, every effort should be made to restore the articular surface. Numerous techniques such as fragment refixation or reconstruction with various materials (autologous or homologous graft, perichondrial graft, or synthetic materials) have been reported.

Fixation of loosened osteochondral fragments was performed by many surgeons using osteochondritis dissecans treatment. In 1957, Smillie\(^6\) proposed for the first time treatment with only drilling or nailing of the fragment; he reported better results using the latter. Many authors\(^6,16-22\) have obtained good clinical results using different fixation methods such as pin or screws, cortical bone pegs, or biodegradable pins. However, some complications such as partial defect healing or fixation loosening have been reported.\(^18,22\) It is important to note that this surgical technique is not available if the loosened fragment is too small or necrotic, and it is contraindicated for patients osteonecrosis of the knee.

Korkala and Kuokkanen\(^23\) reported on nine patients treated with autologous bone graft covered with periosteal graft, and Niedermann et al\(^22\) reported on five knee defects treated with glued periosteal grafts. Both authors obtained good short-term clinical results but recognized that there may be limited application of this technique to large weight-bearing surface defects.

Autologous chondrocyte culture implant was proposed for the first time by Britberg et al\(^25\) in 1991 for the treatment of chondral lesions. This technique is more widely available today and has yielded encouraging clinical results, but the associated extensive bone loss limits its application for the treatment of osteochondral defects.

In a survivorship study of 92 fresh osteochondral allografts performed for post-traumatic knee defects, Beaver et al\(^26\) reported good clinical results in 75% of cases at 5 years after transplantation and in 63% at 14 years. McDermott et al\(^27\) reported a 56% rate of success in 90 patients treated with fresh allografts after 6 years of follow-up. Other authors\(^13,28,29\) have reported variable success rates that differ greatly depending on the patient’s age, the grade of joint destruction, and the defect etiology. All authors agree that the high failure rate is correlated with the immune response of the host organism to allogeneic bone. The biological cycle from the beginning to complete allograft revascularization takes from 2 to 4 years, and during this time, the bony structure is weak.

The reason for the delay in revascularization may be that the immune response delays the graft incorporation and its subsequent replacement by host.
bone, which explains the high incidence of mechanical failure 2 or 3 years after implantation. We agree with some authors such as Meyers et al, who suppose that clinically successful osteochondral allograft can "buy time" for older patients with disabling pain that has not been relieved by other surgical procedures but are too young for total knee replacement. However, this type of treatment cannot be proposed for the young active patient.

The use of autografts instead of allografts is preferred by many surgeons, not only for its higher regeneration potential but also for the reduced risk of hepatitis or infection (including human immunodeficiency virus). Moreover, specialized and expensive facilities for the harvesting and preservation of grafts are not necessary with autografts. Various modalities of using autografts for osteochondral defect reconstruction have been proposed. They differ in donor site change, methods of application, and graft fixation.

Koshino reported a better clinical outcome in six patients with spontaneous knee osteonecrosis treated with osteotomy and bone grafting than in patients treated with osteotomy and arthroscopic drilling. His technique consisted of curettage and cancellous bone grafting of the necrotic zone through a tunnel made inside the femoral condyle, preserving the articular cartilage cover. It is significant to note that this surgical procedure can be performed only for stage II-III osteonecrosis when the cartilage is still intact, but not for stage IV osteonecrosis or full-thickness deep osteochondral defects. The iliac crest cancellous bone plug was successfully used by Perez Caro et al for a large full-thickness defect of the lateral femoral condyle, but they reported only one case with 2 years of follow-up.

Mosaicplasty proposed by Hangody et al consists of arthroscopically reconstructing chondral lesions with press-fit positioning of small osteochondral plugs. Considering their encouraging clinical results in all 44 patients treated with this method as well as 10 good results in 12 patients reported by Bobic, clinical application of this technique may become widespread for knee chondral lesions. One serious limitation of this procedure is the impossibility of its application in osteonecrotic lesions or in deep osteochondral lesion, when the osseous bed destruction grade does not permit adequate press-fit fixation of the small plugs.

Outerbridge et al used the lateral face of the patella to repair large osteochondral defects of the femoral condyle weight-bearing surface in 10 patients, while Crova et al used an analogous procedure in a short-term clinical study of 4 patients. Both reported functional improvement and symptom alleviation in all of their patients. However, Outerbridge noted donor site pathology symptoms such as anterior knee pain or lateral patellar tilt in 8 of their 10 cases.

Wagner and Muller used a portion of the posterior femoral condyle as a donor site and reported excellent results after 4 years of follow-up. With et al used the same technique and reported a satisfactory clinical outcome in 11 of 12 knees. This technique was contested by other authors because of its contact with the meniscus and tibial articular cartilage at the time of flexion. Yamashita et al used the anterior aspect of the medial femoral condyle that was in contact with neither the patella nor the meniscus and reported good results in 2 patients after 2 and 3 years of follow-up.

In our study, 12 of 13 patients treated with autologous osteochondral graft transplantation obtained excellent or good clinical results. We chose the superior aspect of the lateral femoral condyle as the donor site because of its low interference with patellar tracking and the absence of contact with the meniscus or the tibial plateau during joint motion. This was confirmed by the fact that none of our patients had patellar tilt or anterior knee pain at follow-up examination. Clinical and radiographic examinations confirmed good integrative capacity of the autologous graft and also survival of the chondral transplant.

Our one poor result confirmed other authors' findings that bipolar osteochondral transplantation rarely yields a good clinical outcome, probably due to the insufficient mechanical properties of the implant. Better clinical results were achieved in younger patients without knee axial deviations, but older patients who also underwent associated surgical procedures such as osteotomies were satisfied with their knee joint function.

**CONCLUSION**

Large osteochondral defects situated on the weight-bearing surface of the femoral condyle should be reconstructed surgically, independently of their nature, in young or middle-aged (16-60 years) patients. Autologous osteochondral transplantation is a valid therapeutic solution for the treatment of deep osteochondral defects of the knee in these patients.

**REFERENCES**

11. Mont MA, Tomaz IM, Hungerford DS.