Autologous Osteochondral Graft Transfer

Knee and Shoulder Section, Department of Orthopaedic Surgery, Eulji Medical Center, Eulji College of Medicine, Seoul, Korea

Nam-Hong Choi, MD

Introduction

The successful treatment of chondral and osteochondral defects of the weight-bearing surfaces is a challenge for orthopaedic surgeons. Autologous osteochondral transplantation is one method that can be used to create hyaline or hyaline-like repair in the defect area.

The transplantation of multiple Autologous osteochondral plugs (mosaicplasty) is a well accepted technique. It first was described by Matsusue et al in 1993 and has been used with success by several investigators. The technique involves removing small osteochondral plugs retrieved from the periphery of the femoropatellar joint or the margin of the intercondylar notch, and transplanting them into defects of the weight-bearing areas of the knee, thereby making it possible to maintain the radius of curvature of the articular cartilage surface.

Basic researches

1. Effect of graft height mismatch on contact pressure

After defect creation, peak contact pressure were significantly elevated by ~ 20%, and were reduced to normal when plugs were flush. There were large and significant increases in pressure with plugs elevated 1 and 0.5 mm. Contact pressures with plugs sunk 0.5 and 1 mm were significantly ($P < .01$) higher than intact cartilage but were significantly ($P < .01$) lower than an empty defect.

2. Effect of graft height mismatch on resurfaced cartilage

Three months postoperatively, the 2-mm proud grafts had been repositioned by weight bearing but perigraft fissuring and fibroplasia, and subchondral cavitations were serous complications.

Cartilage-to-cartilage healing did not occur. In flush specimens, cartilage changed minimally in thickness and histologic architecture. The specimens countersunk 1 mm demonstrated significant cartilage thickening (54.7% increase, $P < .05$). Chondrocyte hyperplasia, tidemark advancement, and vascular invasion occurred at the chondroosseous junction, and the surface remained smooth. Cartilage necrosis and fibrous overgrowth were observed in all grafts countersunk 2 mm.

3. Effect of graft size on resurfaced cartilage

group I: same donor and recipient size, group II: 1-mm larger donor size

Histologic examination revealed an increase in cartilage thickness and cell density during the implantation period. Round and polygonal hypertrophic clusters of chondrocytes with cytoplasmic vacuoles were observed. By contrast, in group II, the thickness of the articular cartilage was almost the same as that of the normal adjacent cartilage with no significant change observed.

4. Histologic analysis of the implanted cartilage in exact-fit

Macroscopically, there was smooth continuity of the articular surface and the integration of the graft to the normal host cartilage. Histologic examination showed that the layer of the grafted cartilage was thicker than that of the normal host cartilage. Cell density was higher in the grafted cartilage, particularly in the middle and the deep zones. Round and polygonal hypertrophic clusters of chondrocytes were observed in the middle and deep zones of the grafted cartilage.

5. Influence of graft size, repeated insertion, and harvesting technique on primary stability of press-fit-implanted osteochondral grafts

Failure loads of 10-mm-long grafts (mean, 47 N) were significantly lower than failure loads of 15-mm-long grafts (mean, 93 N) and 20-mm-long grafts (mean, 110 N). Reinsertion of the 15-mm-long grafts after initial pullout resulted in a significant reduction of failure loads (mean, 93 N versus 44 N). Levering of the tubular chisel during graft harvest significantly decreased press-fit stability as compared with simple turning of the chisel (mean, 32 N versus 52 N).

6. Evaluation of donor site healing response

Histologic examination showed heterogeneous areas of dense fibrous tissue, bone, and discrete areas of cartilage. Mechanical testing using a confined compression testing technique determined the equilibrium stiffness as 0.97 MPa. The majority of dense fibrous

tissue and areas of bone are likely responsible for the observed increased stiffness.

7. Biomechanical evaluation of osteochondral transplantation

The 12-week grafts (1213.6±309.0 N/mm) had significantly higher stiffness than the 6-week grafts (483.1±229.1 N/mm; $P < .001$) and of normal cartilage (774.8±117.1 N/mm; $P < .003$). Stiffness of the 6-week grafts was significantly lower than normal cartilage ($P < .036$). The grafts demonstrated cartilage viability, yet with a persistent cleft between the graft and host.

8. Topographic matching of donor and recipient sites of the articular surface of the femoral condyles

For cartilage defects within the weightbearing portions of the medial or lateral femoral condyles, grafts taken from sites from the most medial or lateral portions of the patellar groove provided a significantly better topographic match than did grafts taken from the central intercondylar notch.

9. Chondrocyte death associated with osteochondral harvest as performed for Mosaicplasty

There was a substantial margin of superficial zone cell death (mean thickness, 382 ± 68.2 ?m). Mosaicplasty is associated with an extensive margin of cell death that is likely to compromise lateral integration and articular reconstruction.

10. Treatment options of full thickness chondral defect

group 1, transfer of cultured chondrocytes; group 2, transfer of cultured mesenchymal stem cells; group 3, repair by periosteal graft; and group 4, mosaicplasty.

All of the contralateral knees served as control. Gross, histologic, and biomechanical examinations at 36 weeks after the operation showed that the cultured chondrocytes and mesenchymal stem cells had comparable enhancing effects on the repair of chondral defects in advanced osteochondritis dissecans, whereas mosaicplasty did well initially and periosteal graft did less favorably.

Surgical technique

A. Basic problems of the autologous osteochondral resurfacement:
  1. Lack of the appropriate donor area if large chondral defects
  2. Congruency problems
  3. Technical difficulties

B. Indications :
  1. Type of the defect: localized, full thickness defect
  2. Size: 1~4 cm^2 (〉 4 cm^2; consider chondrocyte transplantation)
  3. Age limit: up to 50
  4. Recipient site: femoral and tibial condyles, occasionally, patellofemoral surfaces

C. Pre-op considerations :
  1. limb alignment
  2. stable or unstable knee
  3. meniscal surgery

D. Practical considerations:
  1. Technique of graft havest
  2. Congruence and flush with surrounding cartilage
  3. Press fit fixation for the requirements of the rehabilitation
  4. Arthroscopic technique???

E. Rehabilitation:

immediately full range of motion ⇨ non weight bearing period for 2-3 weeks⇨

partial loading period (30~40 kg) ⇨ full weight bearing from the 4^{th} or 6^{th} week

E. Clinical results:

During the last 10 years more than 800 mosaicplasties have been performed. Experiences of 81 control arthroscopies and histological evaluations of 58 biopsies supported the data of the animal trials. Modified HSS score, modified Cinncinatti score and Lysholm score have been used to evaluate the clinical outcome in the femoral, tibial and patellofemoral implantations. Femoral and tibial implantations gave good to excellent results in 92% while the patellofemoral cases had only 78% success rate.

Multicentric comparative studies have also been performed to compare the efficacy of arthroscopic Pridie drilling, abrasion arthroplasty, microfracture and mosaicplasty. According to them a hyaline like resurfacement represented by the mosaicplasty gave better clinical outcome than "fibrocartilage type resurfacements". Difference of the success rate is higher after 3, 4 and 5 years post-op.