Medium-term outcome of mosaicplasty for grade III-IV cartilage defects of the knee

Maria Mercedes Reverte-Vinaixa,1 Nayana Joshi,1 Eugenio Wenceslao Díaz-Ferreiro,1 Jordi Teixidor-Serra,1 Rosa Domínguez-Oronoz2

1 Department of Trauma and Orthopaedic Surgery, Hospital Universitari Vall d’Hebron, Universitat Autonoma de Barcelona, Barcelona, Spain
2 Institut del Diagnostic per la Imatge, Unitat de Ressonancia Magnetica, Hospital Universitari Vall d’Hebron, Barcelona, Spain

ABSTRACT

Purpose. To evaluate the medium-term outcome of mosaicplasty for full-thickness cartilage defects of the knee joint in 17 patients.

Methods. Records of 12 men and 5 women aged 16 to 57 (mean, 35) years who underwent mosaicplasty for grade III/IV osteochondral defects in the lateral (n=14) or medial (n=3) femoral condyle were reviewed. 12 of the patients had undergone knee surgeries. The mean size of the defects was 3.4 (range, 1–4) cm². Three patients had defects of >2 cm². All operations were performed by a single surgeon using mini-arthroscopy. The lateral edge of the trochlea was the donor site. Graft integration and the presence of any abnormality at the articular surface were assessed using magnetic resonance imaging (MRI). In addition, patients were evaluated using the International Knee Documentation Committee (IKDC) rating scale, the SF-36 health questionnaire, visual analogue scale (VAS) score for pain.

Results. Two of the 17 patients developed necrosis and cystic degeneration of the grafts and underwent conversion to unicompartmental knee arthroplasty within 2 years. They were older than 45 years and had defects of >2 cm². Respectively in years 4 and 7, one and 4 patients were lost to follow-up, the mean IKDC score was 75% and 88%, the SF-36 score was 83% and 90%, and the VAS score was ≤3 in 13 of 14 patients at year 4 and in all 11 patients at year 7. At the 7-year follow-up, patient satisfaction with mosaicplasty was excellent in 8 patients, good in 3, and poor in 2 (who underwent unicompartmental knee arthroplasty). At year 4, MRI showed integration of the cartilage repair tissue and incorporation of the osseous portion of the graft into the bone in 13 of the 14 patients. The remaining patient had osteoarthritis at the graft donor site. At year 7, MRI showed good integration of the implant in all 11 available patients, but fissures were seen on the cartilage surface in 3 patients.

Conclusion. The medium-term outcome of autologous mosaicplasty for symptomatic osteochondral defects in the femoral condyle is good. Longer follow-up is needed to determine the structural and functional integrity of the graft over time.

Key words: cartilage, articular; knee joint; transplantation
INTRODUCTION

Articular cartilage is composed primarily of extracellular matrix with a small cell population and lacks blood vessels. It has a very elaborate and ordered structure that enables mobility with low friction in the synovial joints. Articular cartilage defects in the knee occur in various clinical circumstances and at different ages. Articular cartilage has a limited capacity for healing. In young, active patients, arthroplasty is not recommended because of the risk of instability and the limited lifespan of implants, and treatments should be directed to repair the articular cartilage.

There are 2 biological treatment approaches. One promotes fibrocartilage development (abrasion arthroplasty, drilling, and microfracturing). The other promotes hyaline-like cartilage formation (osteochondral autografting, refrigerated osteochondral allografting, periosteal arthroplasty, perichondral arthroplasty, chondrocyte transplantation, and use of biodegradable materials). Mosaicplasty is effective for resurfacing osteochondral defects of the knee. Osteochondral autograft plugs are harvested from a less-important weight-bearing area and inserted into holes drilled at the defect site of the knee joint. Mosaicplasty can be performed in a single procedure and involves a relatively brief rehabilitation period, but its main drawbacks are limited graft availability and concerns about donor-site morbidity. We evaluated the medium-term outcome of mosaicplasty for full-thickness cartilage defects of the knee joint in 17 patients.

MATERIALS AND METHODS

Records of 12 men and 5 women aged 16 to 57 (mean, 35) years with a mean body mass index of 26 (range, 18–32) kg/m² who underwent mosaicplasty for grade III/IV osteochondral defects in the lateral (n=14) or medial (n=3) femoral condyle between December 1999 and November 2003 were retrospectively reviewed. All patients had symptoms of pain, locking or persistent swelling. The onset of the symptoms was acute in 13 patients and progressive in 4. Patients with open physes, associated tibial, patellar, or trochlear cartilage damage, osteoarthritic changes, rheumatoid arthritis, collagen disease, or mechanical axis malalignment were excluded.

12 of the patients had undergone knee surgeries, which included partial meniscectomy (4 lateral and 2 medial), anterior cruciate ligament reconstruction (n=1), exploratory arthroscopy (n=3), and cartilage shaving (n=2). The mean size of the defects was 3.4 (range, 1–4) cm². Three patients had defects of >2 cm². According to the Outerbridge classification of chondral defects, grade 0 was defined as normal cartilage, grade I as cartilage with softening and swelling, grade II as a partial-thickness defect with fissures on the surface that do not reach subchondral bone or exceed 1.5 cm in diameter, grade III as fissuring to the level of subchondral bone in an area with a diameter >1.5 cm, and grade IV as exposed subchondral bone.

All operations were performed by a single surgeon using mini-arthrotomy. The lateral edge of the trochlea was the donor site. A total of 47 osteochondral autografts were obtained; the mean number of autografts per patient was 2.8 (range, 1–7); their diameters were 10 (n=32), 9 (n=5), 8 (n=6), 7 (n=2), and 6 (n=2) mm. To visualise the edges of the defect, the recipient site was prepared by removing loose fragments with a curette. The osteoarticular transfer system (OATS) was used. After graft implantation, the full knee range of motion was checked for stability. The joint was drained, and a compression bandage was applied. Standardised rehabilitation was initiated 24 hours later.

Continuous passive motion from 0° of extension to 60° of flexion was started and could be advanced to 90° of flexion. Static quadriceps exercises were performed to avoid adhesions and enhance joint nutrition. In the first 4 weeks, partial weight bearing with crutches was allowed (no braces were used). Between weeks 4 and 6, full weight bearing were allowed, and cycling and swimming exercises were started to increase strength. Slow line running was allowed at around month 6, and high-impact activities at around month 12.

Graft integration and the presence of any abnormalities at the articular surface were assessed at month 6 and years 1, 4, and 7 by a single radiologist blinded to the clinical outcome, based on magnetic resonance observation of cartilage repair tissue parameters. These entailed filling of the defect (complete, hypertrophy or incomplete), integration to the border zone, appearance of the surface (damage, ulceration, fibrillations, fissures), structure (homogeneity, cleft formation), and the subchondral lamina and subchondral bone.

At the 4- and 7-year follow-ups, patients were asked to complete the International Knee Documentation Committee (IKDC) rating scale and SF-36 health questionnaire. The residual pain was evaluated using a visual analogue scale (VAS). Patient satisfaction with the procedure was graded as excellent, good, fair, or poor.
RESULTS

Of the 17 patients, 2 developed necrosis and cystic degeneration of the grafts and underwent conversion to unicompartmental knee arthroplasty within 2 years. They were older than 45 years and had defects of >2 cm². Respectively in years 4 and 7, one and 4 patients were lost to follow-up, the mean IKDC score of available patients was 75% (range, 36–100%) and 88% (range, 69–98%), the SF-36 score was 83% (range, 64–93%) and 90% (range, 81–95%), and the VAS score was ≤3 in 13 of 14 patients at year 4 and in all 11 patients at year 7. At the 7-year follow-up, patient satisfaction with mosaicplasty was excellent in 8 patients, good in 3, and poor in 2 (who underwent unicompartmental knee arthroplasty).

At month 6, 5 patients had persistent oedema around the graft, which had resolved at year 1. At year 1, in 15 patients the MRI revealed surface congruency and correct graft integration and no signs of fissuring or delamination (Fig. 1). The remaining 2 patients developed necrosis and cystic degeneration of the grafts (Fig. 2a). At year 4, MRI showed integration of the cartilage repair tissue and incorporation of the osseous portion of the graft into the bone in 13 of the 14 available patients. The remaining patient (aged 17 years) had osteoarthritis at the graft donor site (Fig. 2b) and refused further surgery. At year 7, MRI showed good integration of the implant in all 11 available patients, but fissures were seen on the cartilage surface in 3 patients.

DISCUSSION

Articular cartilage injury in the knee causes pain,
swelling, and locking. The lesions can progress to early osteoarthritis; the treatment goal is to delay or prevent osteoarthritis. In our study, the medium-term outcome of mosaicplasty for symptomatic osteochondral defects in the femoral condyle of relatively young patients (<45 years) was good in terms of SF-36, IKDC, and VAS scores, patient satisfaction, and MRI results.

Treatments that promote fibrocartilage growth (abrasion arthroplasty, drilling, and microfracturing) have poor biomechanical characteristics, and early favourable clinical results deteriorate over time.2,6,8 Thus, they are not recommended for younger patients. Treatments that promote hyaline-like cartilage formation (osteochondral autografting, refrigerated osteochondral allografting, periosteal arthroplasty, perichondral arthroplasty, chondrocyte transplantation, and use of biodegradable materials) can restore normal biomechanical parameters and prevent early osteoarthritis. Their outcome is favourable, but the optimal regenerative technique for treating full-thickness articular cartilage defects in the knee is unknown.13 Autologous mosaicplasty rebuilds an articular surface with properties similar to those of hyaline cartilage,3,9,14,15 while avoiding disease transmission or immunological reactions. However, its drawbacks are limited graft availability, donor-site morbidity, and a disparity in orientation, thickness, and mechanical properties between donor and recipient cartilages. Furthermore, the dead space between cylindrical grafts may limit the quality and integrity of the repair. Nonetheless, autologous mosaicplasty has been successful with few complications (Table).9,11,16–20

Mosaicplasty is superior to autologous chondrocyte implantation, as viable hyaline cartilage is transplanted, rehabilitation is relatively brief, and repair is performed in a single procedure. Although bioengineering techniques are increasingly popular, there is insufficient evidence to draw conclusions on the superiority of autologous chondrocyte implantation for treating full thickness articular cartilage defects in the knee.21

In the largest series of mosaicplasty for chondral defects,9 92% of patients achieved good-to-excellent results. In a randomised study comparing OATS with microfracturing among young athletes,18 96% of patients in the OATS group achieved good-to-excellent results, compared to 52% in the microfracturing group.

Young patients usually achieve better outcome,11,22 because of better graft incorporation and fewer osteoarthritic changes. Nevertheless, for isolated chondral defects good outcome has also been reported in patients older than 40 years.19,20

Although mosaicplasty restores the normal osteocartilaginous architecture of most grafted areas, there is a risk of surface incongruity because of mismatch between the graft and recipient size.7 MRI is a good non-invasive tool to assess articular cartilage abnormalities (signs of fissuring or delamination) as well as surface congruity and integration of the graft.10,14,17,23–25 Nonetheless, it takes at least 12 months to confirm graft integration.

In 3 of our patients, MRI at year 7 showed fissuring of the cartilage surface. Whether this affects graft survival or simply reflects the beginning of osteoarthritis is unknown. Further follow-up is needed to determine the survival of OATS up to 10 years. Clinically, survival of OATS seems to exceed 15 years.12 Factors favouring success are younger patient age (<40 years), smaller lesion size (<2 cm²), and better graft placement (orientation and congruity). In addition, 1 cm² grafts are better than smaller ones.

### Table Outcomes of autologous mosaicplasty in the literature9,11,16,17,20,22,23

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of patients</th>
<th>Mean (range) age (years)</th>
<th>Mean (range) defect size (cm²)</th>
<th>Defect grade</th>
<th>Mean (range) follow-up (years)</th>
<th>Defect site (medial/lateral condyle)</th>
<th>Good-to-excellent results (% of patients)</th>
<th>Good graft integration (% of patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horas et al.,16 2003</td>
<td>40</td>
<td>35.4 (21–44)</td>
<td>3.75 (3.2–5.6)</td>
<td>III</td>
<td>2</td>
<td>-</td>
<td>85</td>
<td>-</td>
</tr>
<tr>
<td>Chow et al.,12 2004</td>
<td>33</td>
<td>44.6 (19–66)</td>
<td>(1–2.5)</td>
<td>III</td>
<td>3.8</td>
<td>28/2</td>
<td>83.3</td>
<td>92</td>
</tr>
<tr>
<td>Gudas et al.,20 2005</td>
<td>28</td>
<td>24.3 (15–40)</td>
<td>(1–4)</td>
<td>III/IV</td>
<td>3 (3–3.16)</td>
<td>23/14</td>
<td>78.3</td>
<td>94</td>
</tr>
<tr>
<td>Maracci et al.,11 2005</td>
<td>30</td>
<td>29.3 (&lt;15–&gt;40)</td>
<td>2.1 (1.8–2.5)</td>
<td>IV</td>
<td>2 (2–7)</td>
<td>23/14</td>
<td>85</td>
<td>84</td>
</tr>
<tr>
<td>Ozturk et al.,23 2006</td>
<td>19</td>
<td>33.1 (20–46)</td>
<td>-</td>
<td>-</td>
<td>4.7</td>
<td>-</td>
<td>92</td>
<td>-</td>
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<tr>
<td>Hangody et al.,9 2008</td>
<td>789</td>
<td>27 (16–47)</td>
<td>-</td>
<td>III/IV</td>
<td>14</td>
<td>-</td>
<td>91</td>
<td>-</td>
</tr>
<tr>
<td>Hangody et al.,17 2010</td>
<td>354</td>
<td>24.3 (14–49)</td>
<td>-</td>
<td>Medial condyle: 2.8 (1–5)</td>
<td>IV/IV (2-17)</td>
<td>187/74</td>
<td>91</td>
<td>-</td>
</tr>
</tbody>
</table>
because of the intrinsic fragility of smaller grafts. Therefore, osteochondral autografts of >1 cm² should be used.

The transplanted cylindrical osteocartilaginous grafts maintain viability and mechanical properties. Despite good positioning and congruity of the graft surface, in some patients transient clinical symptoms persist beyond 6 weeks, but usually resolve within one year.

Research is focused on the development of new biomaterials to provide optimal physical and biochemical conditions for cell proliferation and cartilage synthesis. New forms of cartilage tissue engineering involving stem cells, co-cultures, and platelet-rich plasma are beginning to emerge.

Limitations of our study were small sample size, lost to follow-up of 4 patients, no evaluation of preoperative SF-36 scores, and no histological study of the regenerated tissue. Longer follow-up is needed to determine the structural and functional integrity of these grafts over time.

DISCLOSURE

No conflicts of interest were declared by the authors.

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20. Öztürk A, Ozdemir MR, Ozkan Y. Osteochondral autografting (mosaicplasty) in grade IV cartilage defects in the knee joint.

No conflicts of interest were declared by the authors.