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REVIEW ARTICLE

Chondral repair of the knee joint using mosaicplasty☆

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Summary Mosaicplasty grafting is performed by transferring one or more cylindral osteochondral autografts from a low weight-bearing area of the knee towards the defective site, usually the femoral condyle. Numerous biomechanical, histological, animal and clinical studies have evaluated the different technical aspects of this procedure. The preoperative work-up encompasses an evaluation of functional disturbances, alignment, knee stability and imaging (CT arthrography or MRI with cartilage sequences). The surgical procedure includes harvesting the grafts by mini-arthrotomy of the medial or lateral trochlea and a stage for arthroscopic graft insertion. The ICRS classification is used to describe the defect (area, depth, location) before and then after debridement. A few, large diameter grafts are harvested from the trochlea across from the defect. The graft plugs are transplanted by press-fit, flush with the cartilage, along a convergent plane in recipient sockets of exactly the same depth. Each stage, harvesting, drilling and insertion is repeated until all the full-thickness gap region has been covered. Postoperative movement is free but weight-bearing is delayed for 2 to 4 weeks. Mosaicplasty is indicated in young patients (under 50), with symptomatic chondral or osteochondral defects of less than 3 cm in the weight-bearing part of the femoral condyle. Pre-osteoarthritis is an absolute contraindictation for this procedure. Any misalignment (of more than 5°) or sagittal instability is treated simultaneously. This is a difficult and demanding procedure.

Articular cartilage has a very low potential for spontaneous repair [1,2]. Deep chondral defects in a weight-bearing area are at high risk of progressing to osteoarthritis [3,4]. The frequency of chondral defects is 63%, but only 5% of these are deep defects (ICRS grades III and IV) in patients under 40 [5]. Treatment of focal substance loss in the knee is still a difficult and controversial subject in 2011. In the past 50 years, numerous techniques have been attempted to repair focal defects in weight-bearing areas of the knee to obtain tissue called 'hyalin-like' that is as close as possible to hyalin cartilage. At the beginning of the 1960s, multiple holes were drilled into subchondral bone to try to stimulate stem cells and favor mainly fibrochondral regeneration. This technique was re-introduced by Steadman and called ''Microfracture'' [6]. Microfractures are only

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indicated for small, recent substance loss in young subjects [7]. After 1983, autologous cultured chondrocytes were developed by Brittberg and Peterson [8]. The cell cultures obtained by transfer in a cell therapy laboratory where then injected under a periosteal flap. The results were satisfying but the technique is difficult and not completely satisfactory (harvesting and suturing of the flap is difficult, with irregular spatial distribution of the cells). At present, autologous chondrocytes or stem cells are transplanted into a matrix by arthroscopy. Numerous osteochondral grafts were developed in the 1990s, and are extensively used because they are easier and less expensive to perform. This technique can be applied to many different joints: knee, ankle, elbow, shoulder... but this update will be limited to the knee.

Historical background

Several authors have developed a procedure using large osteochondral grafts from the patella [9], the posterior femoral condyle [10], and the medial trochlea [11]. These techniques are invasive, do not provide a congruent graft, and can disturb articular biomechanics.

The use of several osteochondral cylinders can compensate for these disadvantages and the first case was published by Matsusue et al. in 1993 [12]. This was a 15 mm diameter chondral defect of the femoral condyle, associated with an anterior cruciate ligament tear. Bobic [13] published results in 1996 and Hangody developed the multiple graft technique called ''Mosaicplasty'' in 1992 and reported the results in 1997 [14].

Experimental studies in dogs [15] and horses have shown that at 4 weeks, there was osseous integration but that a gap remained in the cartilage between the donor and recipient site; at 8 weeks the connective tissue between the plugs was fibrocartilage; and at 1 year, the cartilage covered 60—70% of the graft area.

Biomechanical and histological background

There are several questions.

What is the minimum sized defect for an indication of chondral graft?

A biomechanical study of cadaveric knees shows a peak in pressure on the periphery of defects greater than 10 mm in diameter [16]. A smaller defect does not influence peripheral pressure. A threshold of 9 mm was defined by Convery et al. in a study of the horse [17]. A threshold of 10 mm has been adopted by numerous authors as an indication for chondral repair in a weight-bearing area [4,8].

What is the importance of the stress reduction provided by an osteochondral graft?

Loss of 16 mm of chondral substance (2 cm^2) in a weight-bearing area of the human femoral condyle increases peripheral stress by 92%. If three 8 mm grafts are implanted, stress is only increased by 35% on the periphery of the defect. Stress in the area of the graft remains less than 30% of intact femoral condyle stress [18].

What is the ideal site for harvesting?

Theoretically an area with low stress whose curve and thickness are similar to that of the recipient site.

Areas with low stress

Garretson et al. [19] studied contact pressure on the sides of the trochlea with electroresistant dynamic pressure sensors during flexion movements between 0 and 105°. Contact pressure was low on the medial trochlea and the lower lateral trochlea. Because of the different widths of these two areas, small grafts should be harvested from the medial trochlea and larger grafts from the low lateral trochlea.

Area with similar convexity

Restoring the curvature of the condyle is important to obtain good distribution of stresses. Any loss in curvature creates a risk of under- or over-stressing the graft. Two cadaveric studies have shown that the medial or lower lateral trochlea (above the intercondylar groove) provides the best curve for condyles because the upper section is more convex. The rim of the groove is flat and can be used to restore the trochlea [20,21].

Area with the best thickness

Cartilage thickness varies depending on the area of the knee and is proportional to stress. Several studies have measured cartilage thickness in different donor sites: medial and lateral trochlea, intercondylar notch by arthroscan [22] or in cadaveric knees [20]. For Thaunat et al., the thickness of the donor site is a mean 1.8 mm (1.33—1.97 mm), and is therefore thinner than that of the condyle weight-bearing area, which is the usual recipient site, and which is 2.5 mm (2.41—2.69 mm). The thickness is greater on the sides of the trochlea compared to the intercondylar notch, especially the lateral side [22].

What is the most reliable harvesting technique?

The study by Keeling et al. [23] comparing harvesting by arthrotomy and arthroscopy showed that grafts (7 mm diameter) had an incongruence of less than 1 mm in 57% and 69% of the cases respectively. Although the arthroscopic technique may be more reliable, it is more difficult, in particular for the lateral side of the trochlea and there is a risk of marginal fractures. Surface incongruence increases graft diameter for the same angular defect.

What factors influence graft stability?

Vertical stability in relation to graft size

Different diameter (8 and 11 mm) and different length (10, 15 et 20 mm) grafts were tested in pig femurs with axial tears. Grafts of 11 mm in diameter and 15 and 20 mm long had the best resistance [24].