Mosaicplasty of the Femoral Head: A Systematic Review and Meta-Analysis of the Current Literature

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Abstract

Osteochondral lesions of the femoral head are rare. For the treatment of these lesions, various joint-preserving procedures, particularly in young, active patients, have been developed. Mosaicplasty is a well-established surgical procedure for the knee. However, there is little evidence that this method can also be used to treat osteochondral lesions in the hip. The indication for cartilage procedures continues to evolve for the knee, and a similar strategy may be adopted for the hip joint. Due to limited evidence and a lack of experience, mosaicplasty treatment of these lesions remains challenging, especially in young patients. This study shows that open and arthroscopic management using the knee and femoral head as donor sites yielded good to excellent short- to mid-term outcomes. For osteochondral lesions of the femoral head, mosaicplasty may be a new alternative treatment option, although this needs to be proven with longer follow-ups and in a larger sample of patients.

Introduction And Background

The most common cause of mechanical symptoms in the hip is labral tears and cartilage lesions [1,2]. Neumann et al. found that up to 76% of patients (from the age of 17 to 76 years old) presenting with mechanical hip complaints have hip chondral lesions visible on magnetic resonance imaging (MRI) [3]. Trauma, labral tears, femoroacetabular impingement (FAI), arthritis, osteonecrosis, and dysplasia have been identified as causative factors [1-4]. Osteochondral lesions of the femoral head account for only about 2% of all osteochondral lesions. A study revealed that the frequency might be as high as 18% in asymptomatic professional hockey players [5]. Cartilage injury of the hip is a risk factor that can lead to progressive joint degeneration and severe disability, especially in young patients due to cartilage’s poor regeneration capabilities. Magnetic resonance arthography (MRA), arthroscopy, and non-contrast 3-Tesla magnetic resonance imaging (3-T MRI) are useful tools for the assessment of internal pathology of the hip [6]. On the arthroscopic evaluation of 457 hips, McCarthy and Lee found that most chondral injuries (59%) were associated with labral tears and were located in the anterior quadrant of the acetabulum [7]. In terms of location, the most common defect area is found in the anterosuperior acetabulum at the chondrolabral junction, usually due to FAI syndrome. In contrast, the most common defect area in the femur is generally found centrally in the head [2].

The treatment of articular cartilage injuries is challenging, especially in weight-bearing joints such as the hip. In addition, there is a concern regarding the safety and efficacy of surgical hip dislocation in managing femoral trauma [8]. However, hip arthroscopy has recently been gaining popularity as a safe, effective, and minimally invasive method of treating acute and chronic pathology [9]. Conservative treatment frequently yields unsatisfactory results because of the underlying injury to the femoral head cartilage and potential loose bodies that may compromise joint function, causing posttraumatic osteoarthritis to proceed rapidly [10]. Joint arthroplasty is the gold standard for reducing pain and restoring function, although in young, active patients, decreased implant longevity is a concern [11-16]. Although total hip arthroplasty (THA) or resurfacing may provide pain relief and return to activity, they might not be suitable options if the acetabulum remains intact. Additionally, young patients’ high activity levels could result in an early revision [17]. Total hip arthroplasty (THA) is indicated in advanced arthritis, whereas for focal chondral injury, various joint-preserving surgical procedures have been developed during the past few years. The majority of them are adaptations of well-known knee surgeries, such as debridement, microfracture, autologous chondrocyte implantation (ACI), matrix-induced autologous chondrocyte implantation (MACI), autologous matrix-induced chondrogenesis (AMIC), osteochondral autograft transplantation, osteochondral allograft transplantation, direct cartilage suture repair, fibrin adhesive, intra-articular bone marrow mesenchymal stem cell (BM-MSC) injection, artificial plug (TruFit®), and, more recently, partial resurfacing of the femoral head [2,3,16,18-22]. These alternative hip-preserving strategies are more useful in patients who are younger. It seems to be a good option to treat full-thickness chondral lesions with compromised

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subchondral bone due to hyaline cartilage and superior mechanical properties compared to fibrocartilage [19]. In mosaicplasty, chondral or osteochondral deficiencies in an affected joint are filled with autologous osteochondral cylindrical grafts from a non-weight-bearing articular surface. Recent studies revealed that mosaicplasty for femoral head osteochondral lesions showed promising results. Reviewing recent research on mosaicplasty and its effects on the hip joint, especially in the long term, was the aim of this study. We presumed that this surgical method would produce acceptable clinical results and a significant improvement in clinical scores in the short-, mid-, and long-term.

Review

Literature review

Search Strategies and Inclusion Criteria

A systematic review was conducted on two databases (MEDLINE/PubMed and Scholar Google) using the keywords “Mosaicplasty,” “Hip osteochondral defect,” “Hip preserving surgery,” and “Hip osteochondral lesion” in the English language between January 1, 2000, and December 30, 2021. The exclusion criteria included age above 45 years, acetabular chondropathy, and femoral head osteonecrosis. Abstracts were screened by two reviewers (EA and PA) independently (population, intervention, comparison, outcomes, and study (PICOS) criteria).

Results

Data were extracted as follows: our review of the literature yielded 2,209 studies, of which 152 were eligible for abstract review and 32 for full-text review. Finally, 16 studies were found to be eligible for inclusion in our review (Figure 1).

FIGURE 1: PRISMA flowchart of the study selection process

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analysis, AVN: avascular necrosis

Fifty-one (51) femoral head mosaicplasty procedures were published in 16 papers [23-38], which included short-, mid-, and long-term (one case) studies ranging from one case to 27 cases (Table 1). The etiology of the osteochondral femoral head defect included 21 trauma, 13 femoroacetabular impingement (FAI), four osteochondritis dissecans (OCD), one chondroblastoma, eight sequelae of Legg-Calvé-Perthes disease, and four epiphyseal dysplasia. There were 21 females and 30 males, with a mean age of 22.1 years, ranging from 15 to 44 years. Forty-seven (47) patients underwent open surgical procedures and four arthroscopic surgery (two retrograde and two antegrade mosaicplasty). The mean osteochondral defect size of the femoral head...
was 2.12 cm (range: 6 × 1 cm to 1 × 4 cm), and the mean number of autologous plungets was two (range: 1-8). The donor site of autologous graft in 10 cases was the ipsilateral knee and in 41 cases, the ipsilateral femoral head. The mean last follow-up was 37 months (range: 6-156 months). The results show good to excellent scores.

| Study (year)/reference | Study design | Number of patients and gender (WF) | Followed up (number) | Mean follow-up time (months) | Mean age (years) | Etiology | Location of the defect | Defect size | Number of plungets | Donor site | Treatment type (arthroscopic/open) | Complications | Results |
|-----------------------|-------------|-----------------------------------|----------------------|-----------------------------|-----------------|-----------|-----------------------|-------------|---------------------|------------|----------------------------------|---------------|---------|
| Hart et al. (2003)     | Case report | 1 M                                | 1                    | 6                           | 28              | Trauma (hip dislocation) | Femoral head | 1.4 × 1.6 cm          | 4           | Ipsilateral lone          | Open         | No      | 100 points (HHS) |
| Nam et al. (2010)      | Case report | 2 M                                | 2                    | 36 (12 and 60)              | 18 (15 and 21)  | Trauma (hip dislocation) | Femoral head | 2 × 3 cm and 1 × 1 cm | 3           | Ipsilateral lone          | Open         | No      | No complaints of pain         |
| Girard et al. (2011)   | Case series | 7 M, 3 F                           | 10                   | 29.2 (20-39)                | 18 (15-21)      | PD (4 hips), epiphyseal dysplasia (4 hips) | Femoral head | 1.3 × 3 cm            | 3           | Ipsilateral femoral head   | Open         | 1 sciatic nerve palsy after improved within three months (12-17) |
| Enne et al. (2012)     | Case report | 1 M                                | 1                    | 6                           | 22              | PD                     | Femoral head | 1.6 × 1.8 cm          | 3           | Ipsilateral lone          | Open         | No      | 96 points (HHS)           |
| Philippone et al. (2012) | Case report | 1 F                                | 1                    | 25                          | 15              | Trauma                  | Femoral head | 0.6 × 1 cm            | 1           | Ipsilateral femoral head   | Arthroscopic   | Labral snapping symptoms | 85 points (HHS) |
| Kocadal et al. (2016)  | Case report | 1 M, 1 F                           | 2                    | 49 (20 and 48)              | 22 (15 and 26)  | Trauma (hip dislocation) | Femoral head | 2 × 0.5-0.8 cm and 1 × 2 cm | 3           | Ipsilateral lone          | Open         | No      | 96 and 100 points (mHHS)    |
| Gürbüz et al. (2015)  | Case report | 2 F                                | 2                    | 13 (12 and 14)              | 22.5 (22 and 23) | FAI                    | Femoral head | 2 × 1 cm and 3.6 cm | 3 and 4      | Ipsilateral lone          | Open         | No      | 85 and 93 points (HHS)     |
| Anthorenass et al. (2015) | Case report | 1 M                                | 1                    | 28                          | 20              | Trauma (hip dislocation) | Femoral head | 2 × 2.5 cm            | 4           | Ipsilateral lone          | Open         | Pain over the scapula heads | 84 points (HHS) |
| Zelen et al. (2016)    | Case report | 1 M                                | 1                    | 158                         | 21              | Trauma (hip dislocation) | Femoral head | 1 cm                 | 1           | Ipsilateral femoral head   | Open         | Pulmonary embolism, lateral hip pain | 130 points (HHS) |
| Kocadal et al. (2017)  | Case report | 1 M                                | 1                    | 26                          | 27              | Trauma                  | Femoral head | 1 cm                 | 1           | Ipsilateral femoral head   | Arthroscopic   | Retinacular mosaikplasty    | No           | 96 points (HHS)           |
| Uchida et al. (2017)   | Report article | 1 M, 1 F                           | 2                    | 25 (14 and 36)              | 38 (18 and 46)  | OCD                    | Femoral head | 0.85 cm and 1 cm      | 1 and 1       | Ipsilateral femoral head   | Arthroscopic   | One HHS improved from 72.5 to 87.5 points, the other from 66.7 to 100 points |
| Johnson et al. (2017)  | Research article | 5 F                               | 5                    | 52 (53), 52, 62, and 54     | 21.7 (16, 21, 25, and 25) | 1 AVN and 4 trauma | Femoral head | 1.4 cm               | 1-3         | Ipsilateral femoral head   | Open         | Hardware removal (20%)     | HHS improved to 85-100 points (no AVN included) |
| Venne et al. (2021)    | Case report | 1 F                                | 1                    | 24                          | 17              | Chondroblastoma         | Femoral head | 2.6 × 1.8 cm          | 3           | Ipsilateral lone          | Open         | No      | Pain-free                 |
| Viamont-Guerts et al. (2019) | Case series | 17 M, 10 F                         | 22                   | 34.1 (12-50.2)              | 29 (7-19-44)    | 11 FAI, 7 trauma, 4 AVN, 2 osteochondritis | Femoral head | 1.6 × 2.5 cm          | 1-6         | Ipsilateral femoral head   | Open         | 1 TKA (4%)                | Their mHHS improved from 56.3 ± 12.8 to 88.4 ± 9.6 (2% disappointed) |
| Paladini-Claeys et al. (2021) | Case report | 1 M                                | 1                    | 52                          | 15              | Perthes disease         | Femoral head | No report             | 3           | Ipsilateral femoral head   | Open         | No      | 83.8% (HHS)              |
TABLE 1: Characteristics of the included studies

| Study | Mean | SD | Confidence Interval |
|-------|------|----|---------------------|
| Trauma | 70.42 | 2.00 | (69.50, 71.34) |
| PD | 68.50 | 1.50 | (66.75, 70.25) |
| FAI | 68.00 | 1.00 | (66.00, 69.90) |
| Dysplasia | 65.50 | 1.25 | (63.50, 67.50) |
| OA | 63.50 | 1.50 | (61.50, 65.50) |

The study of the treatment of femoral cartilage lesions, algorithms have been suggested [2,3,20,43].

Wilson and Jacobs reported the first osteochondral autograft transplantation in 1952 using a patellar graft.

### Discussion

Chondral pathology has been categorized using several different classification systems [19,20]. Sampson proposed a classification system specific to cartilage lesions of the femoral head and acetabulum. Based on this classification, he recommended treatment protocols [42]. Regarding the treatment of femoral cartilage lesions, algorithms have been suggested [2,3,20,43].
for a lateral tibial plateau fracture [44]. However, mosaicplasty for osteochondral lesions was described for the first time by Hangody in 1997, and since then, its popularity has risen [45]. The long-term survival of the transplanted chondrocytes and osteocytes has been demonstrated by histological studies [46-49]. The talus, tibial plateau, patella, humeral capitellum, and femoral head are among the various articular surfaces to which mosaicplasty methods have been applied as a result of their effectiveness in the knee. Hangody and Füles reviewed 831 patients who underwent mosaicplasties over 10 years at their institution and found good to excellent results in 92% of patients with femoral condylar implantations, 87% with tibial resurfacing, 79% with patellar and/or trochlear mosaicplasties, and 94% with talar procedures [50]. In their 17-year prospective multicenter study of 305 knee, 39 talar, and 12 elbow autograft transplantations, Hangody et al. reported the findings. A minor deterioration in their performance was observed during the 10-year follow-up period, although follow-up data still showed good to exceptional results [51]. Hangody and Füles reported that osteochondral transplantation was performed on six femoral heads. However, the specifics of the surgical process and the clinical outcome were not covered [50].

Gole et al. found that an osteochondral graft’s load-bearing had a beneficial impact on cell viability, indicating that grafts positioned in weight-bearing areas will function better than those positioned in other areas [52]. The better results attained by younger patients suggest that age may have an impact on the clinical outcomes of mosaicplasty treatments [10,53]. After evaluating the outcomes of 831 cartilage joints treated with mosaicplasty, Bartha et al. concluded that results are less remarkable after 45 years of age and that 50 may be the maximum age limit [54]. The optimal defect coverage ranges from 1 to 4 cm², depending on the availability of donor sites and other technical factors [54,55]. It has been shown that expanding the criteria to include larger knee lesions (8–9 cm²) results in an increased rate of donor site morbidity [50,54]. Although the majority of authors employed the ipsilateral knee’s lateral femoral condyle for transplant harvesting, Girard et al. hypothesized that the femoral head’s non-weight-bearing portion might be advantageous [25]. They cited Mardones et al. who reported that excision of up to 30% of the anterolateral quadrant of the femoral head did not appreciably affect the proximal part of the femoral head’s ability to bear weight [56]. Smaller lesions may be suitable for the non-weight-bearing part of the femoral head, particularly when only one cylinder is required. However, grafts from the lateral femoral condyle should be used for bigger lesions [30].

Girard et al. and Viamont-Guerra et al. have published case series of mosaicplasty of the femoral head [25,36]. Girard et al. reported 10 patients with osteochondral lesions of the femoral head who underwent mosaicplasty through trochanteric flap hip dislocation. Sequellee of Legg-Calvé-Perthes disease (six hips), spondylo-epiphyseal dysplasia (three hips), and epiphyseal dysplasia (one hip) were the causes of the osteochondral femoral head defect. They used bone grafts from the non-weight-bearing surface of the ipsilateral femoral head with plugs ranging from 6 to 10 mm. It was suggested that non-weight-bearing for six weeks be followed by gradually increasing weight-bearing as tolerated. The mean follow-up was 29.2 (20-39) months. The Postel Merle d’Aubigné score improved from the preoperative period to the latest follow-up, from 10.5 (8-13) points to 15.5 (12-17) points, and the Harris Hip Score increased from 52.8 (35-74) points to 79.5 (65-95) points, respectively [25]. Viamont-Guerra et al. reported a series of 27 mosaicplasties. The osteochondral lesion of the femoral head was 1.6 ± 0.7 (range: 0.8–4.0) cm² in patients aged 28.7 ± 7.4 (range: 19–44) years. The etiology of the osteochondral defect was FAI, posttraumatic, osteochondritis, and avascular necrosis (the four AVN are excluded from our study). In all patients, osteochondral plugs were taken from the non-weight-bearing surface of the femoral head through a minimally invasive anterior (Hueter) surgical approach. The average diameter of the autografted plugs was 8.5 ± 1.3 (range: 6–10) mm. Toe-touch weight-bearing on the operated limb was allowed for the first 4-6 weeks and then progressed to total weight-bearing as tolerated. At the final follow-up, one patient had been revised to total hip arthroplasty (THA) due to persistent hip pain and the development of degenerative coxarthrosis. The average follow-up of the remaining 22 patients was 39 ± 25 (12-90) months. Their mHHS improved from 56 ± 13 to 88 ± 10, and their Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) improved from 45 ± 17 to 81 ± 15. Twenty (91%) patients were very satisfied or satisfied with the surgery [36]. They found that harvesting plugs from the ipsilateral femur via a minimally invasive anterior approach provides satisfactory outcomes and functional improvements. However, they advised that it should be considered for up to 2 cm² (diameter: 16 mm) lesions of the femoral head.

Studies have shown that the long-term clinical outcome after mosaicplasty varies greatly depending on age, gender, and the size of the lesion [31,47,51,54,57-63].

Zelken presented the first long-term follow-up (15 years) as a patient and surgeon after a posttraumatic type II Pijpkin fracture. After the fracture of femoral head fixation, the osteochondral defect of the femoral head was filed with a plug of 10 mm harvested from the non-weight-bearing anterior inferior surface of the ipsilateral femoral head. Mobilized touchdown weight-bearing for the first six weeks postoperatively was allowed, followed by gradually increasing weight-bearing. Thirteen years later, he reported being pain-free with a Harris Hip Score of 100 [31]. Another case with an eight-year follow-up after a successful femoral head mosaicplasty was reported by Kılıçoğlu et al. [57]. However, it was caused by avascular necrosis, which is not one of our criteria [57].

This is the first systematic review of mosaicplasty of the femoral head to our knowledge. This study shows
satisfactory short- and medium-term results and promising in the long term. The comparison among the HHS distributions for different causes showed statistical significance (p < 0.001) overall. More specifically, the pairs that seem to differ considerably are trauma versus dysplasia (p < 0.001), trauma versus PD (p = 0.008), FAI versus dysplasia (p = 0.027), and trauma versus FAI (p = 0.036).

The present study has a number of limitations that should be mentioned. The first limitation is the heterogeneity in surgical techniques, imaging modalities, and groups of patients. The second is that the number of patients remains insufficient overall and in each separate group. The third is the time of follow-up, which is almost short- and medium-term.

Conclusions

The indication for cartilage procedures continues to evolve for the knee, and a similar strategy may be adopted for the hip joint. Due to limited evidence and a lack of experience, mosaicplasty treatment of these lesions remains challenging, especially in young patients. This study shows that open and arthroscopic management using the knee and femoral head as donor sites yielded good to excellent short- to mid-term outcomes. For osteochondral lesions of the femoral head, mosaicplasty may be a new alternative treatment option, although this needs to be proven with longer follow-ups and in a larger sample of patients. Long-term studies and postoperative MRIs would help determine the procedure’s success.

Additional Information

Disclosures

Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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