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HIP

Promising outcomes of hip mosaicplasty by minimally invasive anterior approach using osteochondral autografts from the ipsilateral femoral head

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Abstract

Purpose Recent studies demonstrated promising results of mosaicplasty for femoral head osteochondral lesions using posterior and lateral approaches. This study aimed to evaluate outcomes of mosaicplasty using ipsilateral femoral head autografts by minimally invasive anterior approach. The hypothesis was that this surgical technique would grant satisfactory clinical outcomes with considerable improvement of clinical scores.

Methods A consecutive series of 27 mosaicplasties, to treat osteochondral lesions of the femoral head measuring 1.6 ± 0.7 cm^2 (range 0.8–4.0) in patients aged 28.7 ± 7.4 years (range 19–44), was evaluated using the mHHS and WOMAC scores at minimum follow-up of 12 months. All patients were operated by minimally invasive anterior (Hueter) approach and osteochondral plugs were harvested from the non-weight-bearing portion of the femoral head. Adjuvant osteoplasty was necessary for some patients at the acetabulum ($n = 3$), femur ($n = 14$) or both ($n = 2$).

Results Three patients were excluded due to concomitant periacetabular osteotomies or shelf procedures, one patient could not be reached, and another was revised to THA. This left 22 patients for clinical assessment at 39.4 ± 23.2 months (12.0–90.2). Their mHHS improved from 56.3 ± 12.6 to 88.4 ± 9.9, and WOMAC improved from 45.1 ± 16.9 to 80.6 ± 13.0. Two patients (8.4%) underwent arthroscopy at 13 and 30 months to remove painful residual cam-type deformities. Regression analyses revealed that net improvement in WOMAC decreased with lesion size ($p = 0.002$) and increased with follow-up ($p = 0.004$).

Conclusions Hip mosaicplasty using autografts from the ipsilateral femoral head, performed by minimally invasive anterior approach, granted satisfactory outcomes and functional improvements. Caution is, however, advised for lesions > 2 cm^2 (diameter > 16 mm) which may be a threshold limit for this procedure.

Level of evidence Level IV, Case series.

Keywords Osteochondral lesions · Osteochondral grafts · Mosaicplasty · Hip preserving surgery

Introduction

Isolated osteochondral lesions of the femoral head are rare but cause considerable pain in young and active patients [22]. Osteochondral defects may result from trauma, femoroacetabular impingement, osteochondritis dissecans, avascular necrosis, or sequalae of Legg–Calvé–Perthes disease [3, 11, 14, 17, 22, 30]. In young patients, different surgical strategies have been proposed to repair chondral lesions and restore articular surfaces, including microfracture, autologous chondrocyte implantation, and osteochondral autograft or allograft transplantation [10, 12, 14, 23, 24, 26, 30].

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Since osteochondral autograft transplantation, also known as mosaicplasty, led to satisfactory clinical outcomes in the knee, ankle and elbow joints [2, 16, 19, 31], some surgeons started using it as a possible treatment for femoral head lesions with promising results [3, 11, 14, 21, 22, 25]. Most of these studies included patients that were operated through posterior or lateral approaches [13, 14, 21, 22, 25, 30], sometimes with trochanteric osteotomy [3, 13, 14, 22, 25, 30], often requiring additional incisions to harvest osteochondral grafts from the knee joint [3, 11, 13, 21, 25, 30]. Recently, some authors proposed less invasive arthroscopic techniques, though such procedures are more challenging to perform [26, 37]. Moreover, all these studies are case reports or small series, which offer weak evidence of the efficacy and safety of mosaicplasty.

Since 2010, the authors have been performing hip mosaicplasty using a minimally invasive anterior approach, believed to minimize soft-tissue damage and preserve blood supply to the femoral head, by virtue of muscle-sparing and inter-nerve techniques [11, 28]. The purpose of this study was to evaluate early outcomes of patients presenting osteochondral lesions of the femoral head, treated with hip mosaicplasty by minimally invasive anterior (Hueter) approach [29, 32] using osteochondral autografts from the ipsilateral femoral head [22]. The hypothesis was that patient reported outcomes scores would be at least equivalent to those reported for other hip mosaicplasty techniques in the literature.

Materials and methods

The authors evaluated a consecutive series of 27 patients that received hip mosaicplasty by direct anterior approach between 2010 and 2016. All patients had provided written informed consent for the use of their data and images for research and publishing purposes and the institutional review board of Clinique de la Sauvegarde (Lyon, France) approved the study in advance (IRB# 2018-NB-MP-002). All patients presented osteochondral lesions of the femoral head, identified on magnetic resonance imaging (MRI), magnetic resonance arthrography (MRA) or computed tomography arthrography (CTA) (Fig. 1). The inclusion criteria were symptomatic anterosuperior focal osteochondral lesions of the femoral head, with minimal or no acetabular osteochondral lesions, and presence of persistent hip pain and functional impairment, despite conservative treatment (analgesics, anti-inflammatory drugs, and physiotherapy) over a minimum of 6 months. The exclusion criteria were: concomitant reconstructive bone procedures such as periacetabular osteotomy ($n=2$) or shelf procedures ($n=1$). This left a study cohort of 24 patients.

Preoperative assessment

Each patient was assessed before the operation by his or her surgeon, who noted demographic data, activity level according to the Devane scale [9] (used routinely by the authors to document activity level for joint arthroplasty patients), the modified Harris Hip Score (mHHS) [7], and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) [5, 6]. The surgeons also noted any concomitant hip pathologies, such as post-traumatic sequelae, avascular necrosis, osteochondritis, or femoroacetabular impingement (FAI) (cam-type deformity in cases with alpha angle > 55° or pincer-type deformity in cases with focal cranial acetabular retroversion) [15, 33].

Surgical technique

The 24 patients were operated by three surgeons (FL, NB, OM), who contributed nearly equally (9, 8, and 7 patients, respectively), under general or spinal anaesthesia in the supine position on an orthopaedic traction table. A

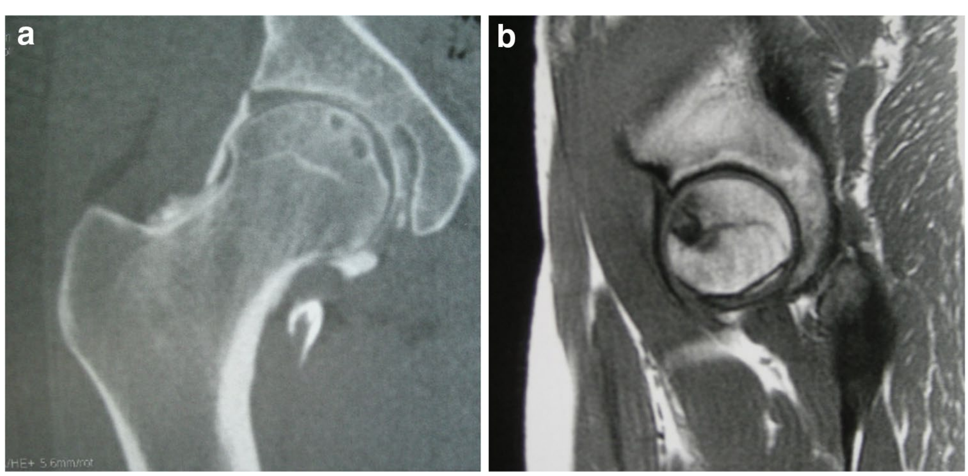

Fig. 1 Preoperative images of a 22-year-old woman with a symptomatic lesion of the right hip. **a** Coronal CTA image showing a focal osteochondral defect in the superior portion of the femoral head. **b** Sagittal T1-weighted MRI image showing the focal osteochondral defect, but no acetabular osteochondral lesion

minimally invasive anterior (Hueter) approach was performed with the standard oblique or transverse incision of 8–10 cm [29, 32]. A V-shaped or T-shaped capsulotomy was made, taking care to avoid damage to the labrum. The hip was then anteriorly dislocated by traction, external rotation, adduction, and hyperextension. During the external rotation, the ligamentum teres was cut from the fovea. The osteochondral defect of the femoral head (Fig. 2a) was measured and debrided until healthy subchondral bone was visible and cartilage edges were stable. A trochar was then used to prepare cylindrical holes, measuring 6–10 mm in diameter, to receive cylindrical osteochondral autograft plugs, harvested using the same trochar from the non-weight-bearing portion of the femoral head, close to the bone-cartilage junction (anterior–inferior portion in 18 patients and superior portion in 6 patients) (Fig. 2b). Depending on the size of the debrided femoral defect, the number of autografts harvested ranged from 1 to 8 plugs, measuring 6–10 mm in diameter, and 10–15 mm in depth. The donor plugs were placed at the debrided osteochondral defect site, taking care to recreate the femoral head curvature, and to respect the cartilage surface level (Fig. 2c). Adjuvant procedures were necessary for 19 patients: osteoplasty at the acetabulum ($n = 3$), femur ($n = 14$) (Fig. 2d5) or both ($n = 2$), with partial resection of small labral tears ($n = 2$) or complete resection of ossified labrum ($n = 1$). In patients that had femoral osteoplasty, the

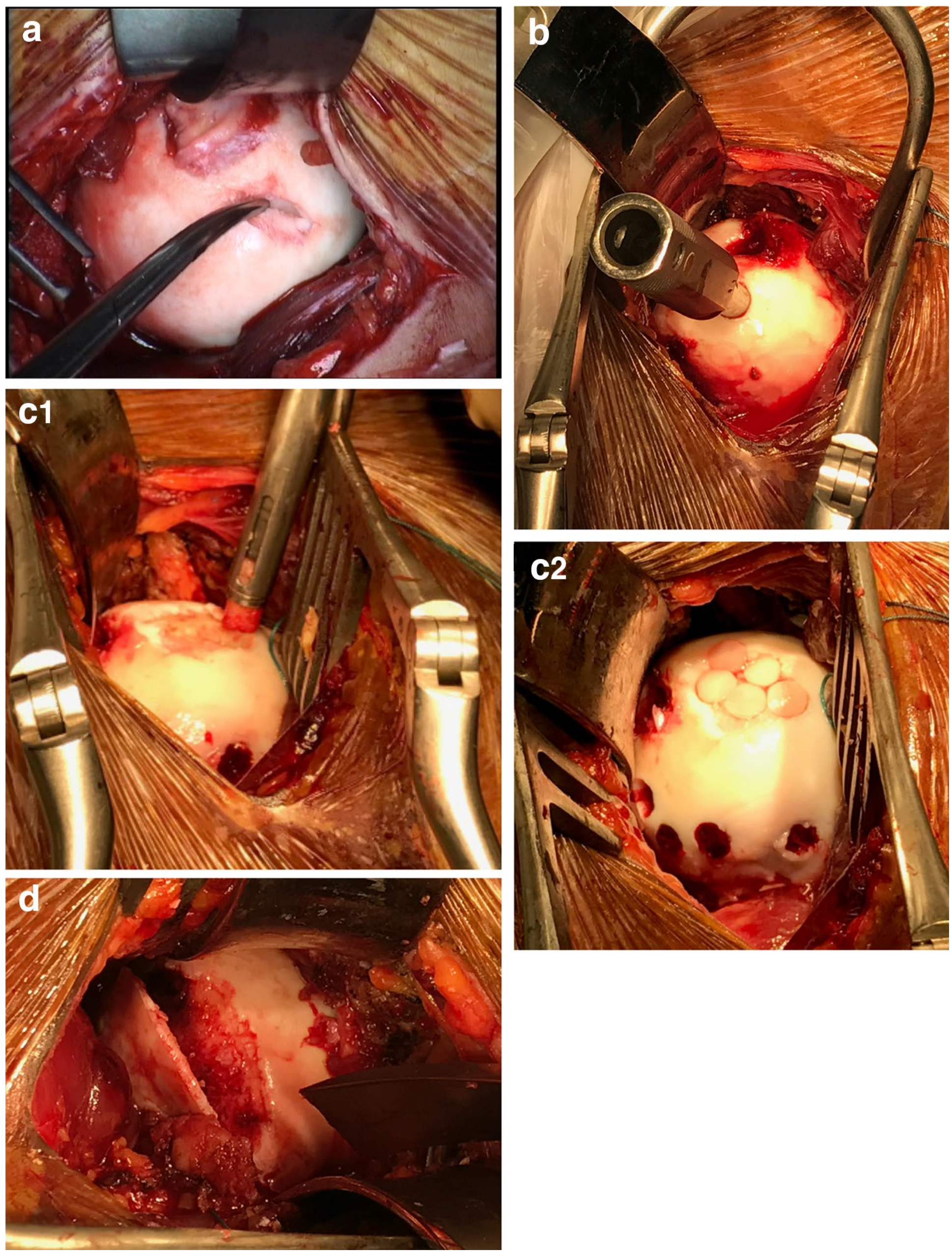

Fig. 2 **a** Intra-operative photograph of an osteochondral lesion of the femoral head before debridement. **b** Harvesting of cylindrical osteochondral autograft plugs from the antero-inferior portion of the femoral head using a trochar. **c** Intra-operative photographs. **c1** Insertion of osteochondral autograft plugs into the debrided and prepared lesion site. **c2** The femoral head after implantation of osteochondral plugs flush with the native cartilage surface. **d** Intra-operative view of adjuvant femoral osteoplasty in a patient with concomitant cam-type deformity

resected bone was used to fill the harvest sites. The hip was then reduced and the joint capsule was closed. The fascia, subcutaneous tissue and skin were separately closed.

Postoperative rehabilitation

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. Active sagittal plane motion exercises were allowed after the first 3 weeks.

Postoperative assessment

All patients were assessed at a minimum follow-up of 12 months by the same independent clinician who noted any complications or reoperations, and collected the mHHS as well as subjective patient satisfaction (very satisfied, satisfied, disappointed, dissatisfied). In addition, all patients completed WOMAC score questionnaires, with no interference from medical staff.

Statistical analyses

Shapiro–Wilk tests were used to assess the normality of distributions. For non-Gaussian quantitative data, differences between groups were evaluated using Wilcoxon rank sum tests (Mann–Whitney *U* test). For non-Gaussian categorical data, differences between groups were evaluated using Fisher's exact tests. Univariable linear regressions were performed to determine associations between net improvements of two outcomes (mHHS and WOMAC) and 13 independent variables (age at surgery, body mass index (BMI), gender, operated side, Preoperative Devane score, etiology and size of femoral osteochondral lesion, presence of labral lesion, surgery duration, graft diameter, number and harvest sites, and follow-up). The two variables that were most significantly associated with one of the outcomes in the univariable analysis were included in a bivariable regression model to eliminate confounding effects. The bivariable analysis was deemed sufficiently powered as per the recommendations of Austin and Steyerberg of minimum 10 subjects per variable [4]. Statistical analyses were performed using R version 3.3.2 (R Foundation for Statistical Computing, Vienna, Austria). P values < 0.05 were considered statistically significant.

Results

The initial cohort of 24 patients comprised 7 women (29%) and 17 men (71%). Their mean age at surgery was 29 ± 7 years (range, 19–44) and their BMI was 23 ± 3 kg/m^2 (range 19–29). The most common concomitant pathology of the femoral head was FAI in 11 (46%) and post-traumatic sequelae in 7 (29%), and the mean lesion size was 1.6 ± 0.7 cm^2 (range 0.8–4.0). Labral lesions were observed in 8 hips (33%), 5 being small partial labral tears and 3 having an ossified labrum. The average diameter of autograft plugs was 8.5 ± 1.3 mm (range,6–10), and the majority of patients (79%) required 2–4 autograft plugs. (Table 1).

At final follow-up, one patient could not be reached (4%) and one patient (4%) had been revised to total hip arthroplasty (THA) due to persistent hip pain and development of degenerative coxarthrosis. The average follow-up of the remaining 22 patients was 39 ± 23 months (12–90) (Table 2). Their mHHS improved from 56 ± 13 to 88 ± 10, and their WOMAC improved from 45 ± 17 to 81 ± 13. Twenty patients (91%) were very satisfied or satisfied with the surgery.

There were no septic or thromboembolic complications. One patient had transient tendinopathy of the gluteus medius

Table 1 Patient demographics and intraoperative data

	Initial cohort ($n = 24$ hips)	
	N (%)	
	Mean ± SD	Median (range)
Age at surgery (years)	28.7 ± 7.4	26.3 (19.1–44.5)
Body Mass Index (BMI)	23.3 ± 2.8	22.9 (19.4–28.6)
Male Gender	17 (71%)	
Right hip	10 (42%)	
Devane activity level		
3	3 (13%)	
4	12 (50%)	
5	9 (38%)	
Concomitant hip pathologies		
Femoroacetabular impingement[a]	11 (46%)	
Cam-type deformity	11 (46%)	
Pincer-type deformity	4 (17%)	
Post-traumatic	7 (29%)	
Avascular necrosis	4 (17%)	
Osteochondritis	2 (8%)	
Lesion size (cm^2)	1.6 ± 0.7	1.6 (0.8–4.0)
Surgery duration (minutes)	78.4 ± 20.2	76.0 (50.0–116.0)
Graft diameter (mm)	8.3 ± 1.3	8.0 (6.0–10.0)
Number of graft(s)		
1	2 (8%)	
2	7 (29%)	
3	7 (29%)	
4	5 (21%)	
5	2 (8%)	
8	1 (4%)	
Graft harvest site		
Antero–inferior	18 (75%)	
Superior	6 (25%)	

[a]Four patients had both cam- and pincer-type deformities

Table 2 Pre- and postoperative clinical outcomes

	Final cohort ($n=22$ hips)	
	Mean ± SD	Median (range)
Follow-up (months)	39.4 ± 23.2	34.1 (12.0–90.2)
Modified Harris Hip score		
Preoperative	56.3 ± 12.6	57.6 (32.0–79.2)
Postoperative	88.4 ± 9.9	89.5 (61.6–100.0)
Net improvement	32.2 ± 14.1	27.8 (11.0–58.0)
WOMAC		
Preoperative	45.1 ± 16.9	48.5 (13.0–76.0)
Postoperative	80.6 ± 13.0	84.5 (39.0–96.0)
Net improvement	35.5 ± 16.0	32.0 (15.0–72.0)
	N (%)	
Patient satisfaction		
Very satisfied	10 (46%)	
Satisfied	10 (46%)	
Disappointed	2 (9%)	
Dissatisfied	0 (0%)	

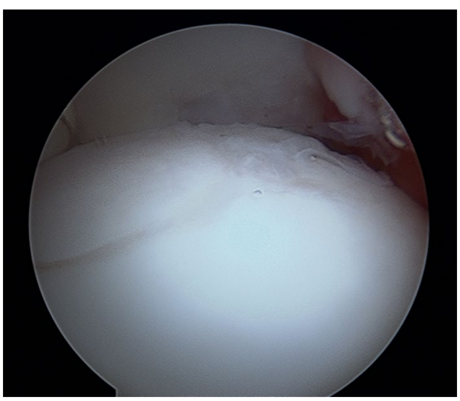

Fig. 3 Arthroscopic view of the cartilage healing and flushness around the osteochondral plug in the femoral head

and another had transient hypoesthesia of the inner thigh, both of which resolved within less than 6 months. Two patients (8%) required reoperation by arthroscopy, at 13 and 30 months, to remove painful residual cam-type deformity. In both cases, the femoral head surface appeared nearly normal during arthroscopic inspection, with satisfactory healing and flushness around the osteochondral plugs (Fig. 3). The first patient presented peripheral chondral detachment (wave sign) at the antero-superior acetabular zone, and International Cartilage Regeneration & Joint Preservation Society (ICRS) grade 2 acetabular chondral lesion in the antero-inferior zone, as well as labrum degeneration and capsulolabral adhesions, which were released. At final follow-up of 17 months, this patient remained disappointed because he could not resume sports at high level, with improvements of baseline mHHS and WOMAC by 40 and 18 points, respectively. The second patient presented peripheral acetabular chondral flaps at the antero-superior zone, as well as sequelae of labrum resection which were debrided. At the final follow-up of 50 months, the patient was satisfied, with improvements of baseline mHHS and WOMAC by 27 and 48 points, respectively.

Uni- and bi-variable regressions revealed that net improvement in mHHS was not significantly associated with any variables (Table 3), but that net improvement in WOMAC significantly decreased with lesion size ($p=0.002$) and significantly increased with follow-up ($p=0.004$) (Table 4). Lesions greater than 2 cm^2 improved less in terms of mHHS ($p=0.120$) and WOMAC ($p=0.017$) than lesions smaller than 2 cm^2 (Fig. 4).

Discussion

The most important finding of the study was that hip mosaicplasty, using osteochondral autografts from the ipsilateral femoral head, performed by minimally invasive anterior approach, grants satisfactory outcomes (in 91%) with improvements above the minimal clinically important difference (MCID) of mHHS [8] and WOMAC [1] (by 32.2 ± 14.1 and 35.5 ± 16, respectively). Although rare, osteochondral lesions of the femoral head are painful and debilitating in young and active patients. As cartilage has a low capacity for regeneration, if left untreated, osteochondral lesions can

Table 3 Regression analyses of modified Harris Hip Score (mHHS) net improvements

Variables	Univariable analyses ($n=22$ hips)		Bivariable analyses ($n=22$ hips)	
	Regression coefficient (95% CI)	*p* value	Regression coefficient (95% CI)	*p* value
Age at surgery (years)	– 0.20 (– 1.09–0.69)	n.s		
Body Mass Index (BMI)	– 0.11 (– 2.54–2.32)	n.s		
Male gender	5.97 (– 8.20–20.14)	n.s		
Right hip	– 2.13 (– 15.00–10.75)	n.s		
Devane activity level	3.79 (– 5.65–13.23)	n.s		
Etiology				
Femoro-acetabular impingement	Ref.			
Post-traumatic	3.53 (– 15.01–22.06)	n.s		
Avascular necrosis	0.13 (– 20.10–20.35)	n.s		
Osteochondritis	9.88 (– 17.26–37.01)	n.s		
Labral lesion	– 3.96 (– 17.20–9.28)	n.s		
Lesion size (cm^2)	– 7.48 (– 15.88–0.91)	n.s	– 7.95 (– 15.93–0.02)	n.s
Surgery duration (minutes)	0.02 (– 0.25–0.29)	n.s		
Graft diameter (mm)	0.41 (– 4.48–5.29)	n.s		
Graft site				
Antero-inferior	Ref.			
Superior	– 2.53 (– 16.93–11.86)	n.s		
Number of graft(s)	– 3.68 (– 7.55–0.20)	n.s		
Follow-up (months)	0.20 (– 0.06–0.47)	n.s	0.22 (– 0.03–0.47)	n.s

Table 4 Regression analyses of WOMAC net improvements

	Univariable analyses ($n=22$ hips)		Bivariable analyses ($n=22$ hips)	
	Regression coefficient (95% CI)	*p* value	Regression coefficient (95% CI)	*p* value
Age at surgery (years)	– 0.43 (– 1.43–0.56)	n.s		
Body mass index (BMI)	– 0.62 (– 3.33–2.08)	n.s		
Male gender	– 3.15 (– 19.41–13.12)	n.s		
Right hip	– 7.42 (– 21.61–6.77)	n.s		
Devane activity level	3.98 (– 6.72–14.68)	n.s		
Etiology				
Femoro-acetabular impingement	Ref.			
Post-traumatic	1.50 (– 19.17–22.17)	n.s		
Avascular necrosis	15.50 (– 14.75–45.75)	n.s		
Osteochondritis	3.50 (– 19.05–26.05)	n.s		
Labral lesion	0.32 (– 14.80–15.44)	n.s		
Lesion size (cm^2)	– 11.80 (– 20.48 to – 3.12)	0.010	– 12.55 (– 19.73 to – 5.36)	0.002
Surgery duration (minutes)	5.97 (– 8.20–20.14)	n.s		
Graft diameter (mm)	– 1.95 (– 7.40–3.51)	n.s		
Graft site				
Antero-inferior	Ref.			
Superior	– 6.48 (– 22.53–9.57)	n.s		
Number of graft(s)	– 4.30 (– 8.66–0.05)	0.053		
Follow-up (months)	0.32 (0.04–0.61)	0.028	0.35 (0.12–0.57)	0.004

rapidly progress and cause degenerative hip disease. While there is no consensus on appropriate hip-preserving surgical management of these lesions [10, 23], hip mosaicplasty has shown satisfactory results [3, 11, 14, 17, 21, 22, 25, 26, 30, 37]. Johnson et al. [22] reported a case series of 5 patients with HHS improvement from 60.8 (range 30–87)

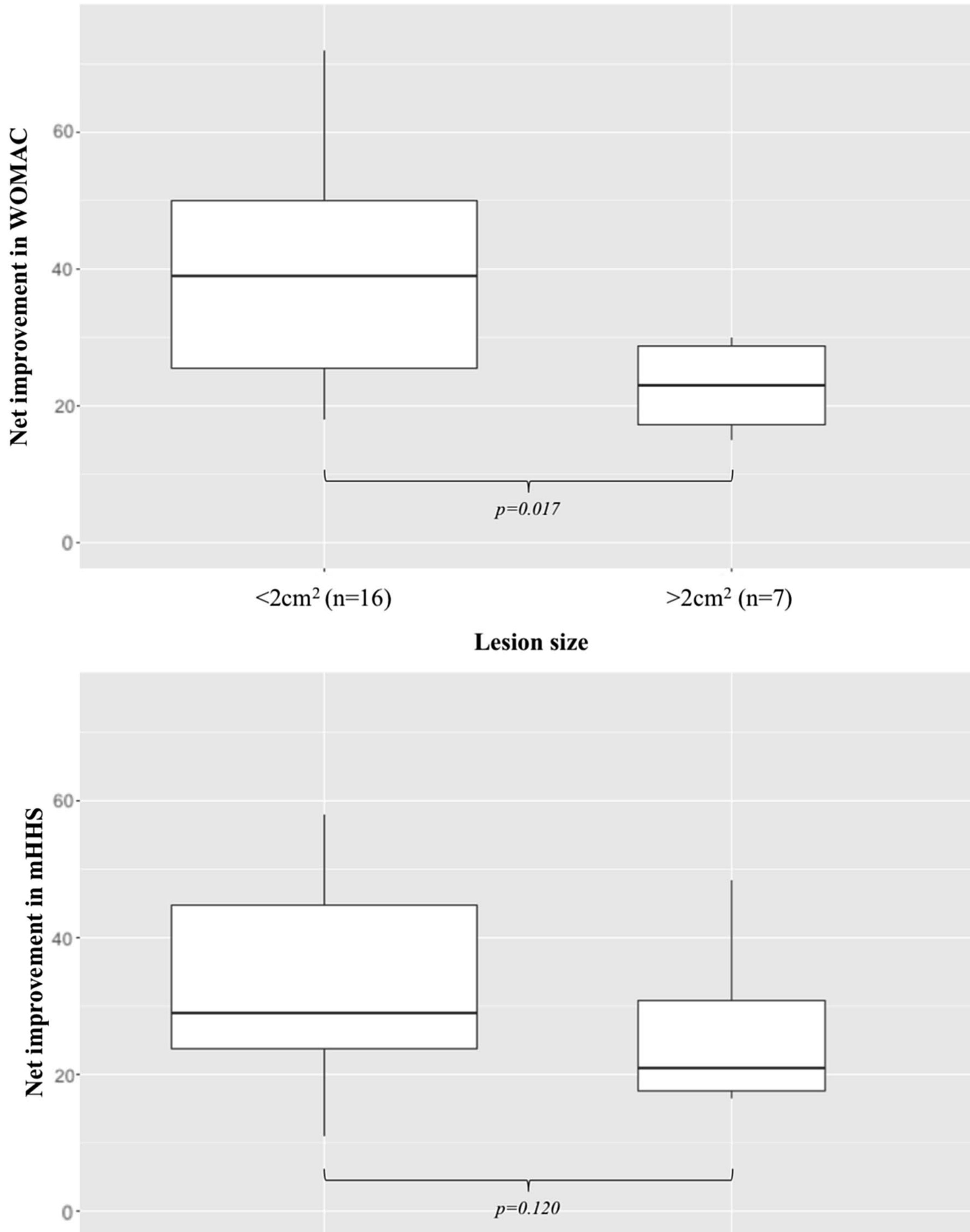

Fig. 4 Net improvements in mHHS and WOMAC depending on initial lesion size

preoperatively to 86.6 (range 44–100) postoperatively. Likewise, Girard et al. [14] reported a case series of 10 patients with HHS improvement from 52.8 (range 35–74) preoperatively to 79.5 points (65–93) postoperatively. The improvement in mHHS for the present series, from 56.3 (range 32–79) preoperatively to 88.4 (range 62–100) postoperatively, compares favourably to other published series and, therefore, confirms the hypothesis that minimally invasive anterior approach grants adequate outcomes for hip mosaicplasty.

The present study has a number of limitations that must be acknowledged. First, it is based on retrospective data from three centres, with some heterogeneity in imaging modalities and surgical techniques used, and neither lesion depth nor ICRS grading were noted. Second, the number of patients remains insufficient to perform sub-group analyses or to affirm findings although, to the authors' knowledge, this series represents the largest cohort of hip mosaicplasty. Third, the inconsistent follow-up times (12–90 months) and X-ray techniques did not permit reliable assessment of FAI correction, and advanced images were not available to assess disease progression or joint degeneration, as most patients had no symptoms to justify the costs and logistics of postoperative MRI or CTA. In the only 2 cases that underwent hip arthroscopy, however, it was possible to evaluate the osteochondral grafts, which confirmed cartilage healing and flush surfaces of the femoral heads. Fourth, most patients had adjuvant osteoplasty and/or labral resection, and it is difficult to ascertain the relative contribution of each procedure, as well as the placebo effects of surgery and postoperative rehabilitation. Finally, despite encouraging results, the study has relatively short follow-up, and cannot confirm the benefits and safety of hip mosaicplasty in the long-term, notably the maximum number of plugs allowed before risks of fracture or degeneration around the donor site. The main strengths of the study are its relatively sizeable cohort, given the rarity of this pathology and, the use of minimally invasive anterior (Hueter) approach for hip mosaicplasty, with osteochondral autograft plugs from the ipsilateral hip.

The minimally invasive anterior (Hueter) approach used in this study differs from the techniques used in most studies on hip mosaicplasty published so far. First, compared to the posterolateral approach, the Hueter approach is a muscle-sparing and inter-nerve approach that minimizes damage to soft tissues, notably the external rotator muscles, and hence favours rapid recovery and preserves blood supply to the femoral head via the medial circumflex artery [11, 28]. It is important to note, however, that despite the advantages of the Hueter approach for mosaicplasty of anterosuperior femoral head lesions, it would not be suitable in rare cases with posterior femoral head lesions [34]. Second, trochanteric osteotomy is not necessary and, therefore, avoids complications as malunion or bursitis [3, 22]. Third, contrary to most studies, in which osteochondral grafts were harvested from the knee [11, 21, 30, 37], in our study, osteochondral grafts were harvested from the ipsilateral hip. This eliminates the need of additional surgery and reduces donor site morbidity, potentially enabling faster rehabilitation and being cosmetically preferable for young patients [14, 20]. Eventually, arthroscopic hip mosaicplasty would be even less invasive, although case reports published so far are limited to insertion of only one osteochondral graft plug, always harvested from the knee [26, 27, 37].

From the initial cohort of 24 patients, one patient (4.2%) required conversion to THA, at 31 months, due to persistent pain and degenerative coxarthrosis, which underlines the importance of careful patient selection to ensure that they will not develop coxarthrosis in the years to come. Furthermore, two active patients (8.4%) needed arthroscopic reoperation, at 13 and 30 months, to remove painful residual cam-type deformities, which are common reasons of revision in the treatment of FAI [18, 35, 36]. Removal of cam-type deformities is essential for the success of hip mosaicplasty, and could be improved by meticulous preoperative planning on advanced images, which could help the surgeon ascertain whether they can be adequately addressed anteriorly. Despite its small cohort size, the present study revealed two interesting trends, that merit further investigation. First, the mHHS was not associated with any variables in regression analysis, probably due to a 'ceiling effect', despite its widespread use, which limits its validity for research on conservative procedures [38]. Second, the WOMAC seemed to be correlated positively with follow-up and inversely with lesion size. The mean lesion size in our cohort was 1.6 ± 0.7 cm^2 (range 0.8-4.0), which is comparable to other reported values of 0.8–5 cm^2 [3, 21, 25, 30, 37]. Girard et al. [14] reported lesion sizes up to 9 cm^2 and Johnson et al. [22] reported the largest lesions of up to 12.6 cm^2 (lesion diameter of 40 mm). The latter suggested that osteochondral defects of the femoral head smaller than 40 mm in diameter (12.6 cm^2) may be amenable to hip mosaicplasty, though this statement was not supported by specific statistical findings. Although it is a small case series, this study found that lesions > 2 cm^2 had considerably smaller improvements in clinical scores than lesions ≤ 2 cm^2 (Fig. 4). The clinical relevance of these findings is that lesion size may be a prognostic factor, we suggest that lesions greater than 2 cm^2 (equivalent to 16 mm in diameter) may be a threshold for performing mosaicplasty, but further studies with larger cohorts and longer follow-up would be required to confirm this recommendation.

Conclusion

Mosaicplasty by minimally invasive anterior (Hueter) approach using osteochondral autografts from the ipsilateral femoral head granted satisfactory early clinical outcomes. Nevertheless, long-term follow-up in a larger number of patients and postoperative imaging exams could help confirm the success of this surgery. The authors advise caution when performing mosaicplasty for lesions of area > 2 cm^2 (> 16 mm in diameter).

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Authors contributions MRVG participated in data collection, literature review and manuscript writing. NB participated in study design, data collection and manuscript editing. OM participated in data collection and manuscript editing. ALV participated in data collection, literature review and manuscript editing. MS participated in literature review, statistical analysis and manuscript writing. FL participated in study design, data collection, manuscript editing and study coordination. All authors read and approved the final manuscript.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of our institutional research committee.

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