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Autologous Osteochondral Transplantation for Focal Femoral Condyle Defects: Comparison of Mosaicplasty by Arthrotomy vs. Arthroscopy

Maxence **Bordes**¹, Elliot **Sappey-Marinier** *¹, Cécile **Batailler**¹, Sébastien **Lustig**^{1,2},
Elvire **Servien**^{1,3}

¹Orthopaedics surgery and Sports Medicine Department, FIFA Medical Centre of Excellence,
Croix-Rousse Hospital, Lyon University Hospital, Lyon, France

²Lyon University, Claude Bernard Lyon 1 University, IFSTTAR, LBMC UMR_T9406,
F69622, Lyon, France

³LIBM – EA 7424, Interuniversity Laboratory of Biology of Mobility, Claude Bernard Lyon
1 University, Lyon, France

Corresponding author: Elliot Sappey-Marinier

Orthopaedics surgery and Sports Medicine Department, FIFA Medical Centre of Excellence,
Croix-Rousse Hospital, Lyon University Hospital, Lyon, France

Tel.: +33 637 631 959

elliott.sappey-marinier@chu-lyon.fr

ABSTRACT

Background: While many studies have reported the outcomes of open mosaicplasty, data on arthroscopic mosaicplasty are scarce. Only two cadaver studies have compared arthrotomy and arthroscopy. Moreover, the patello-femoral joint, which is the main donor site, has never been assessed using a specific functional score. The objective of this in vivo study was to compare arthrotomy and arthroscopy for mosaicplasty using both a global functional knee score and a specific score of the patello-femoral joint.

Hypothesis: The arthroscopic technique results in better functional patello-femoral outcomes.

Material and Methods: We retrospectively compared two groups of 17 patients who underwent mosaicplasty for focal condylar cartilage defects, at our department between 2009 and 2019. Functional outcomes were assessed using the Kujala score and the Lysholm score, at least 1 year after surgery. The return to sports was assessed using the Tegner score.

Results: Mean follow-up was 67.4 ± 15.9 months in the arthrotomy group and 45.2 ± 35.1 months in the arthroscopy group ($p < 0.01$). Cartilage defect size was similar in the two groups (arthrotomy: 1.21 ± 0.91 cm²; arthroscopy: 0.92 ± 1.23 cm²; $p = 0.052$). The mean Kujala score was 85 ± 21.3 in the arthrotomy group and 91.9 ± 13.7 in the arthroscopy group ($p = 0.064$). The mean Lysholm score was 83.9 ± 19.8 with arthrotomy and 89.5 ± 14.9 with arthroscopy ($p = 0.1$). The Kujala score was greater than 95 in 4 (26%) arthrotomy patients and 13 (81%) arthroscopy patients ($p = 0.003$). The Lysholm score was higher than 95 in 4 (26%) arthrotomy patients and 12 (75%) arthroscopy patients ($p = 0.012$). No patient underwent surgical revision for autograft failure.

Discussion: This is the first clinical study comparing arthrotomy and arthroscopy for mosaicplasty. Clinical outcomes were good with both techniques. The proportion of patients with excellent Lysholm and Kujala functional scores was significantly higher in the arthroscopy group than in the arthrotomy group. This result may be ascribable to decreased donor-site morbidity obtained with arthroscopy.

Level of evidence: IV, retrospective observational comparative study.

Key words: Knee; Cartilage; Arthroscopy; Mosaicplasty; Autologous osteochondral transplantation

I. Introduction

Autologous osteochondral transplantation (OAT) by mosaicplasty is a surgical technique used to treat cartilage defects of the knee. Many studies have demonstrated good outcomes in this indication [1–27]. The first arthroscopic mosaicplasty was performed in 1993 by Matsusue et al. [28]. Since then, arthrotomy has been the surgical approach used in most published studies on the topic [1–18].

Few data are available on the morbidity associated with mosaicplasty. The main source of morbidity is the femoral trochlea, which is the main donor site. In a recent literature review, the mean prevalence of donor-site morbidity (DSM) was 5.9%, with a range across studies of 0% to 92% [29]. The long-term incidence of patello-femoral osteoarthritis remains unknown. Standardised evaluations of DSM were performed in four studies using the Bandi score [1,3,6,12]. The Kujala score has never been used, although it is the most relevant tool for evaluating the patello-femoral joint [30,31]. Also, few studies used investigations to assess DSM: magnetic resonance imaging visualised scar tissue at the donor sites [2,20], and Kock et al. reported increased patello-femoral uptake during scintigraphy, with a decline in the medium term [4]. DSM was the primary endpoint only in studies of autologous cartilage taken from the knee for transplantation onto the talus [32–37]. The results of these studies cannot be readily transposed to the clinically pathological knee.

Good outcomes have been obtained in studies that used arthroscopy alone to perform mosaicplasty at the knee [19–27]. Only two cadaver studies have compared arthrotomy and arthroscopy for mosaicplasty [38,39]. They showed that the harvested cartilage was of similar quality with both techniques.

No clinical studies have compared arthrotomy and arthroscopy for mosaicplasty. Moreover, whether arthroscopy decreases the morbidity associated with mosaicplasty has never been investigated.

The objective of this in vivo study was to compare arthrotomy and arthroscopy for mosaicplasty using both a global functional knee score and a specific score of patello-femoral joint function. We hypothesised that the arthroscopic approach would result in better functional patello-femoral outcomes.

II. Material and Methods

1. Methods

We conducted a retrospective comparative study of patients enrolled between April 2009 and April 2019. Consecutive patients who underwent OAT to treat femoral condyle defects were included. Concomitant surgical procedures did not prevent inclusion. Exclusion criteria were OAT at the tibial plateau, patella, or trochlea. Since 2016, all mosaicplasty procedures were performed arthroscopically.

2. Operative technique

Senior surgeons performed all surgical procedures, using the disposable dedicated tool COR Precision Targeting System™ (Synthes Mitek®, West Chester, PA, USA) or OATS™ (Arthrex®, Naples, FL, USA). After debridement, the defect was measured using templates of known diameters. This step allowed the determination of the diameter and number of plugs needed.

The procedure was performed by arthrotomy or arthroscopy. Arthrotomy was via a medial or lateral parapatellar incision. The autograft was harvested at the distal end of the lateral and/or medial border of the trochlea, using a trocar of appropriate diameter. The trocar was impacted perpendicularly to the donor site, under direct visual or arthroscopic guidance.

The receiving site was then drilled using a trocar of the corresponding diameter. Finally, the autograft was impacted using the appropriate dedicated tool. The knee was mobilized to check that graft implantation was regular.

No substitute was used to fill the donor site. The depth of autograft collection was 15 to 20 mm, plug diameter was 6 to 10 mm, and the number of plugs varied from 1 to 3.

The post-operative management was identical in both groups. Full weight bearing on the operated leg was not allowed for the first 6 weeks. Rehabilitation therapy involving active and passive knee mobilization was started immediately.

3. *Patients*

The patients who underwent mosaicplasty at the knee for focal condylar defects were divided into two groups, one group operated on by arthrotomy and the other by arthroscopy. Patient distribution is illustrated in Figure 1. There were 17 patients in each group. Among them, 2 in the arthrotomy group and 1 in the arthroscopy group were lost to follow-up. There was a prior history of surgery on the same knee in 7 arthrotomy patients and 4 arthroscopy patients. The prior surgical procedures that had an impact on the patello-femoral joint were as follows: medial patello-femoral ligament reconstruction in a female in the arthroscopy group and anterior cruciate ligament (ACL) reconstruction using patellar tendon in 2 arthrotomy patients and 1 arthroscopy patient.

All defects were smaller than 2.5 cm² except in 1 arthrotomy patient (4 cm²) and 1 arthroscopy patient (5 cm²). In the arthrotomy group, the donor site was the medial border of the trochlea in 11 patients and the lateral border in 5 patients. In the arthroscopy group, the donor site was the medial border of the trochlea in 14 patients and the lateral border in 3 patients. In each group, 1 patient had cartilage collected from both the medial and the lateral borders of the trochlea.

During the mosaicplasty, one or more concomitant surgical procedures were performed in 4 arthrotomy and 4 arthroscopy patients. ACL reconstruction using the patellar tendon was performed in 2 arthrotomy and 3 arthroscopy patients. Reconstruction using hamstring tendons was carried out in 1 patient in the arthroscopy group. Medial open wedge high tibial osteotomy was done in 1 patient in each group and suture of a meniscal tear in 3 patients in each group. Finally, partial meniscectomy was performed in 2 arthroscopy patients.

4. *Evaluation*

The post-operative follow-up was provided by the surgeon. All patients were assessed 3 months post-operatively and 22 patients 12 months post-operatively. Finally, all patients were evaluated by phone between February and April 2020. The date of the telephone call was taken as the date of last follow-up.

Functional outcomes were evaluated by determining the Kujala score [30,40] and Lysholm score [41]. In addition, the Tegner Activity Scale was chosen to assess the return to sports [42]. Secondary outcome measures were joint range of motion as assessed during the post-operative physical examination and the occurrence of complications involving the operated knee.

The R programme was used for the statistical analysis. Quantitative variables were compared by applying the Mann-Whitney test and qualitative variables using Fisher's exact test. Values of $p < 0.05$ were considered to indicate significant differences.

III. Results

1. Demographic data

At last follow-up, 3 patients were unavailable, leaving 15 patients in the arthrotomy group and 16 in the arthroscopy group for the analysis. Table 1 reports the comparison of

demographic and surgical data. Mean follow-up was 67.4 ± 15.9 months in the arthrotomy group and 45.2 ± 35.1 in the arthroscopy group ($p < 0.01$). The mean size of the cartilage defect was similar in the two groups: 1.21 ± 0.91 cm² in the arthrotomy group and 0.92 ± 1.23 cm² in the arthroscopy group ($p = 0.052$). Mean autograft size was also similar: 0.79 ± 0.36 cm² versus 0.67 ± 0.37 cm² in the arthrotomy and arthroscopy groups, respectively ($p = 0.061$). Coverage was 73.5% in the arthrotomy group and 62% in the arthroscopy group ($p = 0.46$). The percentage of patients in whom the autograft was larger than 0.8 cm² was 40% and 19% in the arthrotomy and arthroscopy groups, respectively ($p = 0.25$).

2. Functional outcomes

The mean Kujala score was 85.0 ± 21.3 in the arthrotomy group and 91.9 ± 13.7 in the arthroscopy group ($p = 0.064$). The corresponding values of the mean Lysholm score were 83.9 ± 19.8 and 89.5 ± 14.9 ($p = 0.1$). The Kujala score was above 95 in 4 (26%) arthrotomy and 13 (81%) arthroscopy patients ($p = 0.003$), while the Lysholm score was above 95 in 4 (26%) arthrotomy and 12 (75%) arthroscopy patients ($p = 0.012$). No patient required surgical revision for autograft failure. Table 2 reports the Kujala and Lysholm scores with the comparison of the two groups, and Figures 2 and 3 illustrate the distribution of the two scores. The mean Tegner Activity score was 3.93 ± 2.15 in the arthrotomy group and 4.81 ± 1.33 in the arthroscopy group ($p = 0.11$).

3. Complications

Complex regional pain syndrome Type I was found in 2 arthrotomy patients and 1 arthroscopy patient. A female patient in the arthrotomy group required surgery for knee stiffness. Surgery to remove the tibial osteotomy fixation material was performed in 2 patients. No patient required surgery for autograft failure.

IV. Discussion

This is the first clinical study comparing arthrotomy to arthroscopy for knee mosaicplasty. Moreover, we report the first assessment of patello-femoral function using a specific score after knee mosaicplasty. The mean Kujala and Lysholm scores were higher in the arthroscopy group but the differences were not statistically significant. Nonetheless, the arthroscopy group had a significant larger proportion of patients with excellent values (≥ 95) for the Kujala and Lysholm scores.

The Lysholm score values in previous studies of mosaicplasty are comparable to ours. Emre et al. reported a mean Lysholm score of 88.2 after 18.2 months of follow-up in a study of mosaicplasty by arthrotomy [9]. In an arthroscopic study, Chow et al. found a Lysholm score of 87.5 after 45.1 months of follow-up [19]. In contrast, little information is available on patello-femoral function and DSM. Among arthroscopic studies, 4 found no DSM [20,21,23,24] and 4 others made no mention of DSM [19,22,25,26]. In arthrotomy studies, DSM was evaluated using the Bandi score in four studies and found an incidence of 3% to 5% [1,3,6,12]. The Bandi score is an old tool for assessing patello-femoral function and has not been validated in the recent literature [43]. No studies have reported the Kujala score in this indication.

Our starting hypothesis of better patello-femoral function related to decreased DSM in the arthroscopy group is consistent with the significantly larger proportion of patients with an excellent Kujala score and an excellent Lysholm score in the arthroscopy group. Sparing of the patellar retinaculum may ensure the maintenance of physiological patellar tracking along the trochlea, which is potentially weakened by the autograft harvesting. Biomechanical studies have delineated optimal harvesting zones at the medial and lateral borders of the femoral trochlea [44,45]. At these zones, the match between the curvature of the trochlear

cartilage and the curvature of the femoral condyles is optimal. Another study established that the zone associated with the least risk of iatrogenic complications is the part of the patello-femoral joint where the pressure is lowest. This zone is at the most distal part of the lateral or medial border of the trochlea, just above the sulcus terminalis [46]. Arthroscopy offers a global and detailed view of the trochlea and may therefore allow optimal identification of these sampling zones.

Mean defect size was small in both groups compared to earlier studies: 2.7 cm² (1.5–4.5 cm²) for Emre et al. [9], 2.29 cm² (0.3–12.25 cm²) for Ollat et al. [5], 1.9 cm² (1.1–2.5 cm²) for Marcacci et al. [20], and 2.8±0.65 cm² for Gudas et al. [23]. Furthermore, in the present study, the proportion of patients with defects larger than 0.8 cm² was not significantly different between the two groups. In most studies, defects smaller than 2 cm² were associated with better outcomes in terms of global knee function or return to sports [5,9,23]. The size of the sample may correlate with patello-femoral function and DSM. Hangody et al. recommended reserving mosaicplasty for defects smaller than 4 cm² on the grounds that DSM was excessive for larger defects [3]. For larger defects, other surgical techniques should be considered [47]. However, for defects smaller than 4 cm², the size of the autograft did not correlate with DSM [29].

The number of plugs correlates with DSM [20]. In our study, the number of plugs was similar in the two groups. The mean number of plugs used in our study was small compared to earlier studies: 4 (1-14) for Ollat et al. [5] and 4.3 (3-6) for Gudas et al. [23].

In both groups, the mean defect size was greater than the mean size of the autografts. This difference allows determination of the coverage rate. This criterion was not significantly different between the two groups. The coverage rate points to the limitations of the mosaicplasty technique. We found no reports of coverage rates in the literature. The size of

the plugs influences the coverage rate: narrower plugs lead to a greater coverage rate.

However, wider plugs are more stable [48].

The arthroscopic mosaicplasty method is more demanding technically and has a longer learning curve compared to the arthrotomy technique. A recent literature review showed that the size of the autografts was smaller in arthroscopy than in arthrotomy studies [49].

However, our two groups can be viewed as successive cohorts, since arthrotomy was used in our department until 2016; starting in 2016, all mosaicplasty procedures were done by arthroscopy. Although 3 patients had arthroscopic surgery before 2016, this was the surgeon's usual technique and the choice was not influenced by the size of the defect.

The main limitation of our study is the lack of statistical power due to the small sample size. In addition, several factors may have led to assessment bias: follow-up was longer for the arthrotomy group, prior surgical procedures on the knee varied across patients, and the surgeons were not the same in the two groups. However, the number of concomitant procedures done at the same time as the mosaicplasty was similar in both groups. Finally, the retrospective design and absence of a physical examination and investigations at last follow-up are also limitations.

V. Conclusion

Function, as evaluated using the Kujala and Lysholm scores, was better in the arthroscopy group, although the difference was not statistically significant. However, the proportion of patients with excellent functional scores was significantly higher in the arthroscopy group. This improvement may be ascribable to a decrease in DSM related to the use of arthroscopy.

Conflicts of interests

Prof. Sébastien Lustig is a consultant for Medacta, Heraeus, Corin, Amplitude, Groupe Lépine, Depuy, Smith & Nephew, Stryker. Prof. Sébastien Lustig receives research support from Corin and Amplitude. Prof. Sébastien Lustig is a board member of KSSTA, Maitrise Orthopédique and JBJS am. The other authors declare that they have no conflict of interest.

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Authors contribution

Maxence Bordes, Elliot Sappey-Marinier and Cécile Batailler contributed to write this manuscript. Prof. Sébastien Lustig and Prof. Elvire Servien provided overall supervision of the conduct of this study.

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Tables

Table 1. Demographic and surgical data

	Arthroscopy n=16	Arthrotomy n=15	p value
	N (%) or mean (\pm SD)	N (%) or mean (\pm SD)	
Males	11 (69%)	10 (67%)	1
Body Mass Index	23.7 (\pm 3.15)	25.5 (\pm 4.84)	0.46
Prior surgery on the knee	4 (25%)	7 (47%)	0.17
Site of the defect			
- Medial	11 (69%)	11(73%)	1
- Lateral	5 (31%)	4 (27%)	1
Concomitant lesions(s)			
- PF	4 (25%)	1 (7%)	0.34
- TF	4 (25%)	1 (7%)	0.34
- Meniscus	5 (31%)	4 (27%)	1
Defect size (cm²)	0.92 (\pm 1.23)	1.21 (\pm 0.91)	0.052
- > 0.8cm ²	6 (38%)	9 (60%)	0.21
Autograft size (cm²)	0.67 (\pm 0.37)	0.79 (\pm 0.36)	0.061
- >0.8 cm ²	3 (19%)	6 (40%)	0.25
Number of plugs	1.19 (\pm 0.403)	1.53 (\pm 0.743)	0.16
Harvesting site(s)			
-LBT	3 (19%)	5 (33%)	0.43
-IBT	14 (88%)	11 (73%)	0.39
Concomitant procedure(s)	4 (25%)	4 (27%)	1
-Including PT ACL recon.	3 (19%)	2 (13%)	1

N: Number; PF: patello-femoral cartilage defect; TF: tibio-femoral cartilage defect; LBT: lateral border of the trochlea; IBT: internal border of the trochlea; PT ACL recon: reconstruction of the anterior cruciate ligament using the patellar tendon

Table 2. Results of the functional scores

	Arthroscopy n=16	Arthrotomy n=15	<i>p</i> value
	N (%) or mean (\pm SD)	N (%) or mean (\pm SD)	
Follow-up (months)	45.3 (\pm 35.2)	67.40 (\pm 15.9)	<0.01
Kujala score	91.9 (\pm 13.7)	85 (\pm 21.3)	0.064
-Kujala score \geq 95	13 (81%)	4 (26%)	0.003
Lysholm score	89.5 (\pm 14.9)	83.9 (\pm 19.8)	0.1
-Lysholm score \geq 95	12 (75%)	4 (26%)	0.012
Tegner Activity Score	4.81 (\pm 1.33)	3.93 (\pm 2.15)	0.11
Complications	1 (6.2%)	2 (13%)	0.6

N:
Number

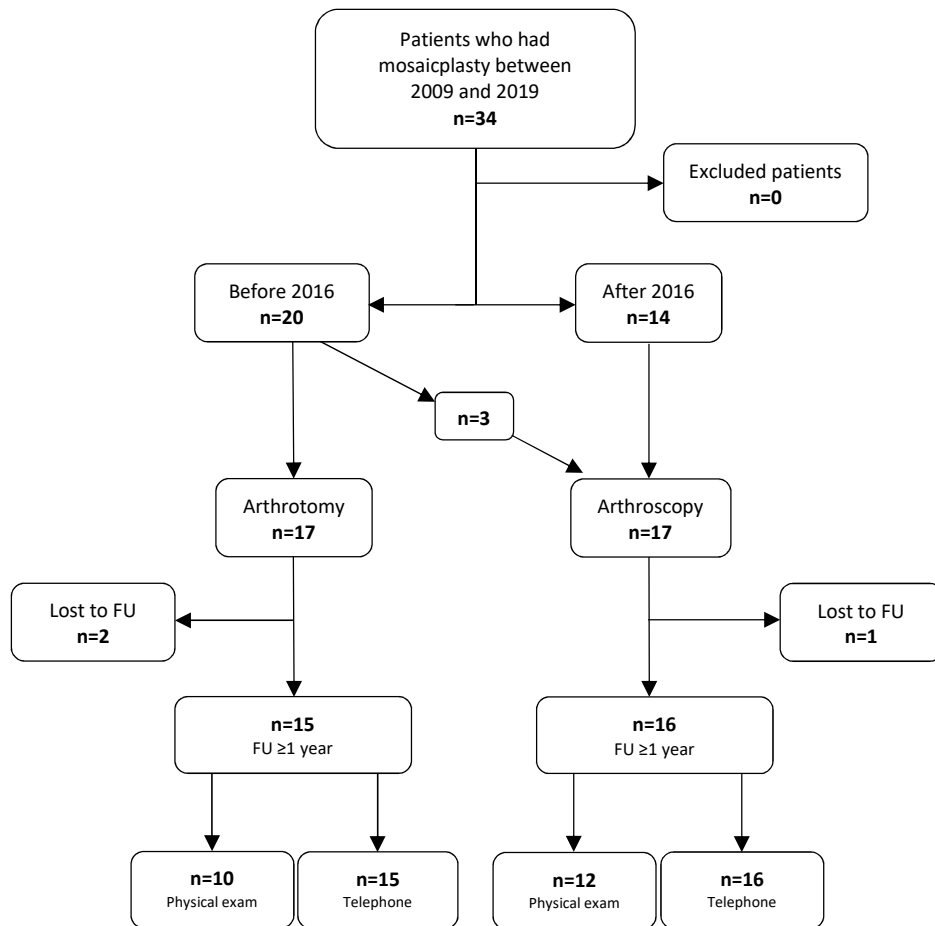
FIGURE LEGENDS

Figure 1. Flow chart

Figure 2. Distribution of the Kujala score values in the two groups

Figure 3. Distribution of the Lysholm score values in the two groups

Figure 1.



Patients who underwent mosaicplasty in 2009–2019
N=34

Excluded patients
N=0

Before 2016

N=20

Arthrotomy

N=17

Lost to follow-up

N=2

N=15 at the minimal FU of 1 year

N=10

Physical examination

N=3

N=15

Telephone

After 2016

N=14

Arthroscopy

N=17

Lost to follow-up

N=1

N=16 at the minimal follow-up of 1 year

N=12

Physical examination

N=16

Telephone

N: number; FU: follow-up

Figure 2.

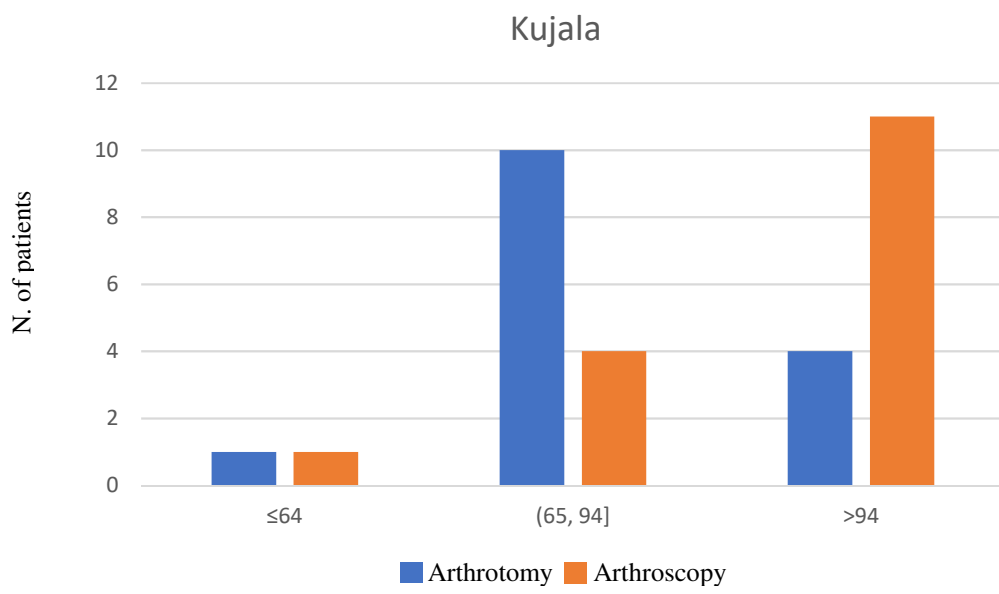


Figure 3.

