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Osteochondral transplantation using autografts from the upper tibio-fibular joint for the treatment of knee cartilage lesions

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Abstract
Purpose Treatment of large cartilage lesions of the knee in weight-bearing areas is still a controversy and challenging topic. Autologous osteochondral mosaicplasty has proven to be a valid option for treatment but donor site morbidity with most frequently used autografts remains a source of concern. This study aims to assess clinical results and safety profile of autologous osteochondral graft from the upper tibio-fibular joint applied to reconstruct symptomatic osteochondral lesions of the knee.
Methods Thirty-one patients (22 men and 9 women) with grade 4 cartilage lesions in the knee were operated by mosaicplasty technique using autologous osteochondral graft from the upper tibio-fibular joint, between 1998 and 2006. Clinical assessment included visual analog scale (VAS) for pain and Lysholm score. All patients were evaluated by MRI pre- and *post*-operatively regarding joint congruency as good, fair (inferior to 1 mm incongruence), and poor (incongruence higher than 1 mm registered in any frame). Donor zone status was evaluated according to specific protocol considering upper tibio-fibular joint instability, pain, neurological complications, lateral collateral ligament insufficiency, or ankle complaints.
Results Mean age at surgery was 30.1 years (SD 12.2). In respect to lesion sites, 22 were located in weight-bearing area of medial femoral condyle, 7 in lateral femoral condyle, 1 in trochlea, and 1 in patella. Mean follow-up was 110.1 months (SD 23.2). Mean area of lesion was 3.3 cm^2 (SD 1.7), and a variable number of cylinders were used, mean 2.5 (SD 1.3). Mean VAS score improved from 47.1 (SD 10.1) to 20.0 (SD 11.5); $p = 0.00$. Similarly, mean Lysholm score increased from 45.7 (SD 4.5) to 85.3 (SD 7.0); $p = 0.00$. The level of patient satisfaction was evaluated, and 28 patients declared to be satisfied/very satisfied and would do surgery again, while 3 declared as unsatisfied with the procedure and would not submit to surgery again. These three patients had lower clinical scores and kept complaints related to the original problem but unrelated to donor zone. MRI score significantly improved at 18–24 months comparing with pre-operative ($p = 0.004$). No radiographic or clinical complications related to donor zone with implication in activity were registered.
Conclusions This work corroborates that mosaicplasty technique using autologous osteochondral graft from the upper tibio-fibular joint is effective to treat osteochondral defects in the knee joint. No relevant complications related to donor zone were registered.
Level of evidence Case series, Level IV.

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Introduction

Proper treatment for cartilage lesions depends on the extent and depth of the defect, usually characterized using a classification score like International Cartilage Research Society (ICRS) grading system [4]. Many surgical treatments have been proposed, namely, arthroscopic lavage [32] and abrasion [34]; augmentation procedures including Pridie's perforations [26] and microfractures [35, 36]; grafting techniques and advanced regenerative medicine approaches using cells [3, 18, 20, 24, 30, 33], gene therapy [5, 25] and growth factors [10]. Since the nineties, mosaicplasty technique has been advanced by Hangody et al. [12, 13] as a way to provide autologous "plugs" of cartilage and underlying bone to damaged areas. Some advantages of this procedure have been stated such as being a single procedure, autograft use without limitations inherent to allografts, capable to address large defects and adapt to defect geometry while providing hyaline cartilage and subchondral bone. However, using grafts harvested from nonweight-bearing bearings of the knee joint some concerns related to donor zone complications have been upraised [1, 28, 37].

For this reason, since the first report of successful application of autologous osteochondral grafting from the upper tibio-fibular joint for the treatment of knee cartilage lesion [8], this once classified as "the forgotten joint" [27] presented as a valuable option to overcome this problem keeping all the aforementioned advantages. Few reports [8, 14] of clinical application subsided, but up to now no serial trial at medium or long-term follow-up has been published.

The aim of this work is to present clinical results and safety profile of mosaicplasty technique using autologous osteochondral graft from the upper tibio-fibular joint applied to reconstruct symptomatic osteochondral lesions (grade 4 according ICRS classification) in load-bearing zones of the knee joint. Our hypothesis is that this joint could provide valuable osteochondral graft source with minimal donor zone-related problems.

Materials and methods

For the period comprised between 1998 and 2006, 31 patients (22 men and 9 women) with osteochondral lesions (grade 4 according to international cartilage repair society-ICRS classification) in the knee were operated by mosaicplasty technique using autologous osteochondral graft from the upper tibio-fibular joint as primary procedure. All patients were prospectively evaluated using visual analog scale for pain and Lysholm score. Last follow-up was performed by an orthopedic surgeon independent of surgical team, and only these scores were considered. All files were available to consult for any further relevant information. MRI evaluation was performed pre- and *post*-operatively from 18 up to 24 months follow-up using a device at 1.5 Tesla field strength (GE Healthcare Signa®) in T1- and T2-weighted sequences including STIR and FatSat. An independent radiologist (blinded for clinical status) classified all cases regarding joint line congruency in a 3 grade score [29]: (1) good (normal smooth joint line), (2) fair (up to 1 mm incongruence), and (3) poor (higher than 1 mm incongruence). Congruency was assessed by measuring the distance from the surface of the cylinder above and the adjacent articular surface in any irregularity detected. The worst classification registered in any frame was assumed as final score.

Donor zone status was clinically evaluated according to specific protocol including upper tibio-fibular joint instability, pain for touch or under pressure, neurological complications, lateral collateral ligament insufficiency, or ankle pain. All parameters were assessed in 4 grades (none, slight, mild, and severe). Imaging evaluation of the upper tibio-fibular joint was available for all patients.

Self-accomplishment evaluation was asked for all patients referring to level of satisfaction and motivation to submit once more to the same procedure in the hypothetical scenario of returning to previous clinical state.

The present study was approved by the Institutional Ethical Committee at the Saúde Atlântica F.C. Porto Sports Center. Written information on the need of patient's participation in long-term follow-up was provided prior to surgery, and standard informed consent was obtained for every patient.

Surgical technique for harvesting the osteochondral grafts from the upper tibio-fibular joint

The surgical procedure starts with a 4-cm vertical skin incision: 1 cm above to 3 cm below the tip of fibula head, 1 cm anteriorly to its vertical plane. Blunt dissection is performed until reaching the upper tibio-fibular joint capsule. Surgical approaches to the proximal upper tibio-fibular joint might endanger the common peroneal nerve (PN), the anterior tibial artery, and the lateral collateral ligament (LCL). The mean distance from the inferior part of the joint to the PN was 19.5 mm (the "safe zone") [9]. LCL is identified and the capsule is divided anteriorly. A blunt dissection should be performed until feeling the fibula neck (FN) and PN beneath the fingers. It is always mandatory to preserve "safe zone" and LCL insertion. A

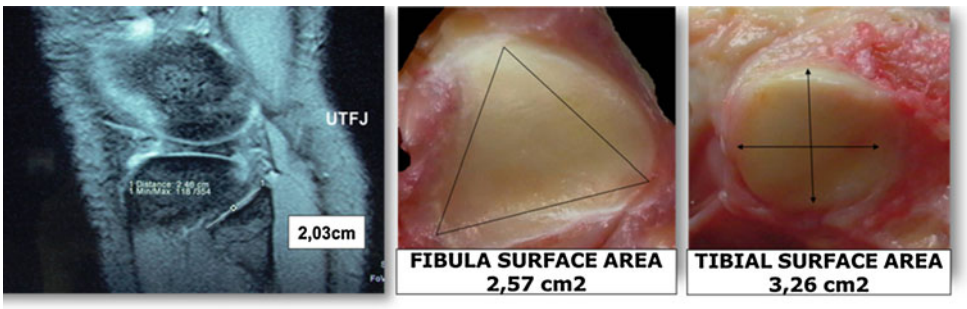

Fig. 1 Images of pre-operative assessment by MRI of the upper tibio-fibular joint; and fibula and tibial mean surface areas

vertical bone cut should be performed by means of using a osteotome or saw until reaching the FN, intersected by a second transverse cut (perpendicularly) thus creating a bone block 12–15 mm in height. The next phase comprehends removal of the second bone block (mean height of 20 mm) from tibial surface, which comprises a wider and thicker cartilage. Before capsule closure, it is recommended to put a graft of fat pad usually from local tissue in order to prevent fusion. The mean tibial surface area is 3.26 cm^2 (SD 0.43), and the mean fibular surface is 2.57 cm^2 (SD 0.36) (Fig. 1). Using a specific stabilizer, several bone plugs are created achieving to cover an area broader than 5 cm^2. The following steps and principles were similar to those described for classic mosaicplasty [11, 13] in order to provide ideal placement of the grafts (Fig. 2).

Rehabilitation

Post-operative mobilization was started on the first day after surgery with a continuous passive motion arthrometer for 4–6 h per day. For lesions on the weight-bearing surfaces on the condyles, the initial range of motion (ROM) was 30°–60°. After 1 week, ROM is progressively increased as tolerated by 10°–20° until full range of motion is obtained. For lesions of the patello-femoral joint, the flexion was limited with a brace for 1 week to 30°, for another week to 60° and until the sixth week after surgery to 90°. Crutch-assisted touchdown weight-bearing ambulation was prescribed for 6 weeks after the surgical procedure. Crutch-free walking was permitted after 2 months. Return to vigorous recreational or sports activities was allowed at 6–9 months, depending on the size of the defect, symptoms, and clinical examination.

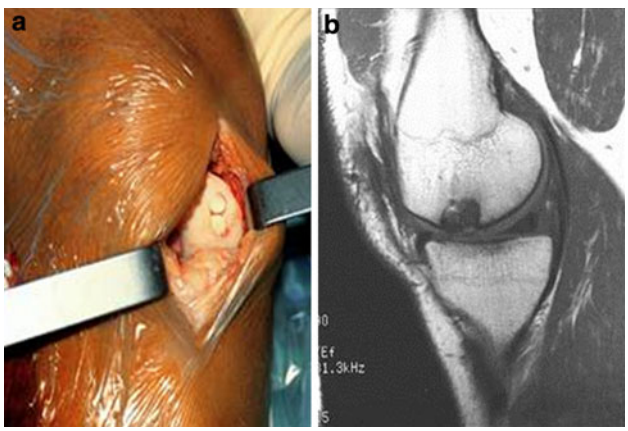

Fig. 2 Photograph of upper tibio-fibular joint osteochondral grafts implanted in defect area (**a**) and MRI image in T-1 sequence at 24 months follow-up (**b**)

Statistical analysis

The statistical analysis was performed by commercial software (SPSS ver. 14.0; SPSS Science, USA). The Mann–Whitney *U* test was used for statistical significance evaluation. Pearson's correlation assessed linear dependence between *post*-operative VAS and Lysholm results and all of the following: age, gender, area of lesion, lesion location, MRI, number of cylinders and follow-up.

Results

All patients were available for follow-up and given informed consent to participate in this study. Mean age at surgery was 30.1 years (SD 12.2). Twenty-two lesions were located in weight-bearing area of medial femoral condyle, seven in lateral femoral condyle, one in the trochlea, and one in lateral facet of patella. Mean follow-up was 110.1 months (SD 23.2), ranging from 47 to 157. Mean area of lesion was 3.3 cm^2 (SD 1.7) and a variable number of cylinders ranging from 1 to 6 were used, mean 2.5 (SD 1.3). From Fig. 3, it can be seen that mean VAS score improved from mean 47.1 (SD 10.1) to 20.0 (SD 11.5; $p = 0.00$). Similarly, mean Lysholm score increased from 45.7 (SD 4.5) to 85.3 (SD 7.0; $p = 0.00$).

Post-operative VAS and Lysholm scores were independent of age, gender, and area of lesion according to Pearson's correlation coefficient. However, VAS was

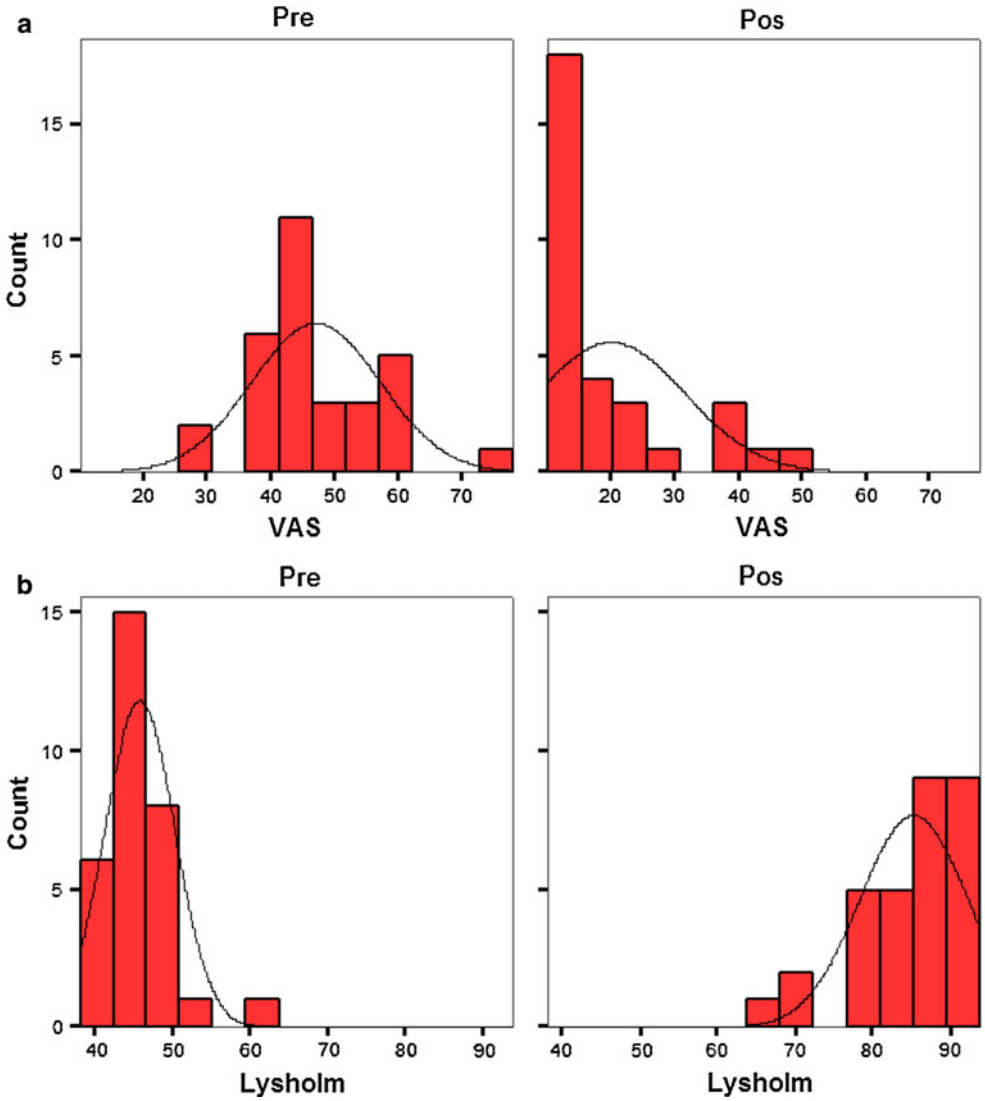

Fig. 3 Histogram of *pre*- and *post*-operative results of patient pain evaluation with VAS (**a**) and Lysholm score (**b**)

directly dependent of area of lesion ($p = 0.023$), meaning that higher area correlates to higher expected VAS score (worse clinical result). Similarly, close to statistical significance, we could sense a tendency for lower *post*-operative Lysholm score in bigger lesions (n.s.). There is a strong correlation between *post*-operative scores and the number of plugs applied. Worse results on VAS and Lysholm score are to be expected when more plugs are used (p of 0.001 and 0.000, respectively). Follow-up is inversely related to clinical outcome (p of 0.036 for VAS and 0.010 for Lysholm).

Twenty-eight patients declared to be satisfied/very satisfied and would do surgery again, while 3 patients declared as unsatisfied with the procedure and would not submit to surgery again in hypothetic scenario of returning to initial status (success rate estimated in 90%). The three unsatisfied patients had lower clinical scores (Lysholm 68, 71, and 72, respectively) and kept feeling pain and effusion episodes in the affected knees when performing recreational activities, such as gardening. They assume to have improved their pre-operative *status* but with insufficient restoration of their capacities. At last follow-up, none of them accepted surgical option to address their situation but assumed that it might be required in future.

MRI evaluation was available pre-operatively and at 18–24 months follow-up for all cases. All were classified as poor pre-operatively and after index surgery 8 were scored as good, 20 as fair, and 3 as poor ($p = 0.004$). MRI score presents significant correlation with VAS ($r = 0.574$, $R^2 = 0.330$, and $p = 0.001$) and with Lysholm ($r = -0.686$, $R^2 = 0.471$, and $p = 0.000$) *post*-operative scores at last follow-up (Fig. 4). The number of plugs shows inverse correlation with joint line congruency assessed by MRI ($p = 0.025$). No significant correlation could be established between MRI score and age, gender, place of lesion, area, or follow-up (n.s.).

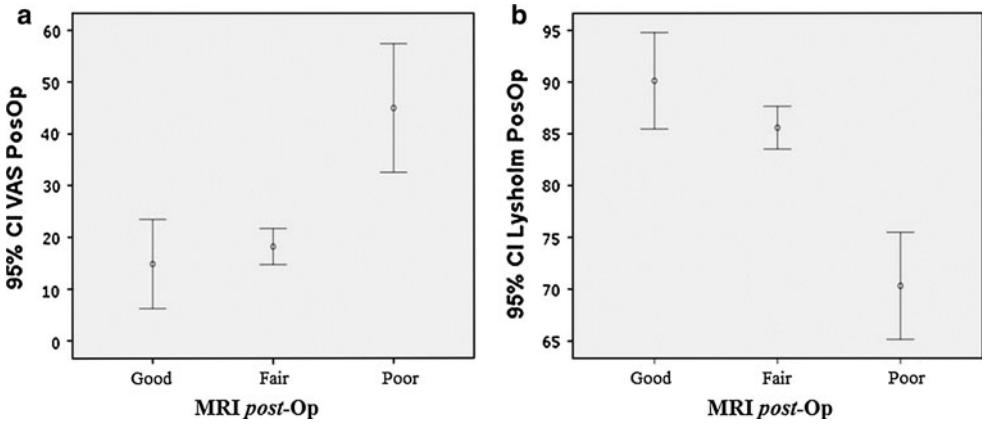

Fig. 4 Correlation between MRI *post*-operative results and VAS (**a**) and Lysholm (**b**) final scores

No radiographic complications such as fusion of the upper tibio-fibular joint at last follow-up were registered. Clinical evaluation of the upper tibio-fibular joint revealed mild pain at manual pressing of the donor zone in two cases but no complaints during walking on straight or uneven ground, stairs descending/climbing and recreational activities such as cycling or gardening. No other complications were registered related to donor zone.

Discussion

The most important finding of the present study is that mosaicplasty technique using osteochondral grafts from the upper tibio-fibular is an effective option to treat osteochondral defects in the knee joint, and no relevant complications related to donor site were observed.

The functions of the superior tibio-fibular joint are poorly determined, but it appears to have some role in the dissipation of torsional, compressive, and tensile forces applied to the fibula. These forces are transmitted through the tibia as well as through the fibula during ankle motion and weight bearing [9, 27].

The upper tibio-fibular joint is rarely a site of complaints. Pathology involving this joint is rare and comprises mainly few symptomatic cysts [23] or instability [22, 31, 39]. Some surgical techniques directed to this joint have been reported ranging from resection [6, 23] to fusion [23] or ligamentoplasties [22, 39] and present minimal associated morbidity in exception of possible neural damage. Besides the aforementioned, the upper tibio-fibular joint has been contentiously neglected for decades during the many years of popularity of Coventry's method for high tibial osteotomy [6]. This author recommended that enough fibula should be resected ranging from "the entire fibula head to the proximal tip". The herein proposed technique to approach the upper tibio-fibular joint and harvest osteochondral grafts brings minimal and controlled damage. Our findings corroborate low risk for donor site morbidity as previously reported [8, 9, 27].

As suggested elsewhere [8, 9, 14], this joint provides a source of hyaline cartilage covered grafts with all the required properties for osteochondral autograft surgery. There are several references in the literature reporting not significantly different results with microfractures, mosaicplasty, and autologous condrocyte implantation [7, 15, 16, 18, 38]. Mosaicplasty presents the advantage of transferring hyaline cartilage into the defect with favorable integration of the cancellous bone component of the "plug" [12, 21]. Integration of the transplanted hyaline cartilage with the adjacent cartilage is provided by fibrocartilage tissue formation between the multiple grafts. This observation has relevant implications since is in line with the noticed tendency for obtaining worst results when using a higher number of plugs. Smaller-sized plugs may be able to fill irregular defects with possibly less donor site morbidity [17]. Nevertheless, smaller grafts are more fragile; have lower pullout strength; and technically, they are more labor-demanding and difficult to harvest and implant [19]. These facts should be considered for subsequent refinement of the technique. Mosaicplasty technique using osteochondral grafts from the upper tibio-fibular joint is less limited and enables harvesting large plugs without further iatrogenic concerns, which is most advantageous as compared to classical donor zones [21].

Our data corroborate that higher number of plugs correlates with worst joint congruency assessed by MRI. Furthermore, the best MRI results gathered at 18–24 months *post*-operatively, i.e., better articular congruence can be a predictor of better clinical outcome at long-term evaluation. This result constitutes another relevant insight of this work. Besides its importance in follow-up, MRI is also useful in the pre-operative planning enabling evaluation of the upper tibio-fibular joint *status* and area available for graft harvesting (Fig. 1).

According to Hangody et al. [11], grafts with 6.5–8.5 mm in diameter are best suited to create good congruency and provide better outcomes once larger-diameter grafts have higher inherent stability. Proper harvesting and implantation

of the plugs are critical to prevent articular cartilage irregularity and "step-off". Nevertheless, overall congruity and contact pressure are improved using fewer plugs for circular defects [2].The general clinical improvement herein reported is in agreement with previous studies, considering mosaicplasty using grafts harvested from nonload-bearing zones inside the knee joint (e.g., the intercondylar notch or the femoral condyle periphery) [7, 11–13].

The observation of results decreasing with time has been reported [11]. If we consider long-term follow-up in young and demanding population, this trend could be expected in certain extent. Moreover, early deterioration has been linked to donor site morbidity [17, 37]. However, this fact is not observed in this series. No relevant donor site complications with influence in outcome at mean 110 months follow-up were registered and this is the most relevant conclusion derived from present study.

It is worth of note that this study lacks a control group and this is probably the most significant limitation. Furthermore, osteochondral lesions in different joint compartments were included and an inherent bias should be considered. In terms of cost-effectiveness profile, it is not clear up to now which is the most efficient approach to symptomatic osteochondral lesions [38], and this issue was also not addressed in the present study. Meanwhile, mosaicplasty is a reproducible approach to provide hyaline cartilage coverage to full thickness defects in osteochondral transplantation. To overcome the issue of donor site concerns, autologous osteochondral transplantation using grafts from the upper tibio-fibular joint needs to be pondered by surgeons and patients.

Conclusion

This work corroborates that mosaicplasty using osteochondral grafts from the upper tibio-fibular joint should be considered as safe, effective and reliable in the treatment of knee' osteochondral defects. In addition, no relevant complications related to donor zone were registered, including ankle problems.

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