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The role of bone marrow edema on osteochondral lesions of the talus

Riccardo D'Ambrosi, M.D.[a,b,*], Camilla Maccario, M.D.[a,b], Chiara Ursino, M.D.[c], Nicola Serra, Ph.D.[d], Federico Giuseppe Usuelli, M.D.[b]

[a] Dipartimento di Scienze Biomediche per la Salute, Università degli Studi di Milano, Milan, Italy
[b] Istituto Ortopedico Galeazzi, U.O. C.A.S.C.O. — Piede e Caviglia, Milan, Italy
[c] Università Vita-Salute San Raffaele, Milan, Italy
[d] Seconda Università degli Studi di Napoli, Naples, Italy

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ABSTRACT

Background: To assess the functional and radiological outcomes after arthroscopic talus autologous matrix-induced chondrogenesis (AT-AMIC®) in 2 groups: patients with and without bone marrow edema (BME).
Methods: Thirty-seven patients of which 24 without edema (GNE) and 13 with edema (GE) were evaluated. All patients were treated with AT-AMIC® repair for symptomatic osteochondral talar lesion. Clinical and radiological parameters were evaluated with VAS score for pain, AOFAS and SF-12 at T_0 (preoperatively), T_1 (6 months), T_2 (12 months), T_3 (24 months) and MRI and CT-scan at T_0, T_1, T_2 and T_3.
Results: No patients were lost to the final follow-up. In both groups we found a significant difference for clinical and radiological parameters with ANOVA for repeated measures through four time points ($p < 0.001$). In GNE, AOFAS improved significantly at each follow-up ($p < 0.05$); while CT and MRI showed a significant reduction in lesion size between T_1 and T_2 and T_2 and T_3 ($p < 0.05$). In GE, AOFAS improved significantly between T_0 and T_1 and T_2 and T_3 ($p < 0.05$); lesion size, measured with CT, decreased between T_1 and T_2 ($p < 0.05$), while with MRI the lesion showed a reduction at each follow-up ($p < 0.05$). Lesion size was significantly higher both in MRI and CT in GE compared to GNE ($p < 0.05$). In GNE no patients presented edema at T_3, while in GE only 23.08% of the patients presented edema at T_3.
Conclusions: The study revealed that osteochondral lesions of the talus were characterized by bigger size both in MRI and CT in patients with edema. We conclude that AT-AMIC® can be considered a safe and reliable procedure that allows effective healing, regardless of edema and more than half of patients did not present edema six months after surgery.

1. Introduction

Bone marrow edema (BME) is a unique imaging characteristic of osteochondral lesion of the talus (OCLTs) identified on MRI surrounding the lesion [1,2]. The clinical and anatomopathological significance of BME is not yet clear, in fact BME identify a wide number of clinical entities, which are all characterized by the same magnetic resonance imaging (MRI) pattern and often by pain as their main symptom, but show significant differences in terms of histopathologic pictures, causal mechanisms and prognosis [3]. Radiologically BME is characterized as an area of different signal on MRI of the bone, showing an intermediate or low signal intensity on T1 weighted images and a high signal intensity on fat-suppressed, T2 weighted, and short tau inversion recovery sequences in comparison with the normal bone marrow [3]. Moreover BME is often associated with an increased local uptake of the tracer on the bone scan. The real meaning of BME from the histopathological point of view is still unclear. The altered signal pattern observed on MRI is probably related to a replacement of normal fatty bone marrow by a more water-rich material [4]. However, it is still unclear how the development and resolution of edema correlate with its intensity and extent of involvement within the talus in particular in surgical procedure [5,6]. Independent prognostic factors such as age, size of the lesion, high body mass index, history of trauma and presence of osteophytes have been shown by some authors to negatively affect the outcome of OCLT repair [6–11]; however, there is currently no general consensus on the prediction of therapeutic success among the various OCLT treatment possibilities, although

* Corresponding author at: Dipartimento di Scienze Biomediche per la Salute, Università degli Studi di Milano, Milan, Italy/Istituto Ortopedico Galeazzi, U.O. C.A.S.C.O. — Piede e Caviglia, Milan, Italy.
E-mail address: riccardo.dambrosi@hotmail.it (R. D'Ambrosi).

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absence of edema is considered to be an advantage in the healing of these lesions [10,12,13]. Cuttica reported that patients with low edema intensity showed significantly better outcomes after microfracture and drilling [12]. The purpose of our study was to assess and evaluate healing and the functional outcome after AT-AMIC® (arthroscopic talus autologous matrix-induced chondrogenesis) in 2 groups: patients with and without BME.

2. Material & methods

This is a retro-prospective study of 37 arthroscopic cartilage reconstructions for OCLTs performed between January 2012 and September 2014 in one center specialized in foot and ankle surgery.

The inclusion criteria for the case series were: osteochondral lesion of the talus Types III and IV according to Berndt and Harty's classification [14], skeletal maturity and ability to give informed consent. Exclusion criteria were: concomitant surgical procedures, previous surgical treatment of the affected ankle, arthritis of the ankle joint, kissing lesions, haemophilia, rheumatoid arthritis, severe metabolic disorders, autoimmune disease, ongoing chemotherapy, radiation treatment or immunosuppression, pregnancy or lactation. Patients satisfying the inclusion and exclusion criteria were divided into two groups: patients with bone marrow edema (GE) on T1 weighted images and a high signal intensity on fat-suppressed, T2 weighted, and with a difference greater than 40 mm^2 between the pre-operative CT-scan and the pre-operative MRI and patients without edema and with a value less than 40 mm^2 between pre-operative MRI and CT were assigned to the non-edema group (GNE).

All subjects gave their written informed consent to participate in the study, which was approved by the Institutional Review Board. The surgical procedures were all performed by the senior author. All surgical interventions were performed using the AT-AMIC® technique previously described [15,16]. Briefly, surgery was characterized by two arthroscopic phases. First, after having achieved an adequate exposure through the use of a Hintermann™ spreader (Integra LifeSciences, Plainsboro, NJ) that allowed for sufficient joint distraction, the lesion was debrided and prepared to receive the regenerative treatment. Cancellous bone was harvested from the ipsilateral calcaneus with an accessory lateral approach on the calcaneus wall. The cancellous bone was introduced using the same cannula and impacted into the bony defect until complete fill was achieved. The second surgical step was performed in a dry condition, during which Chondro-Gide® (Geistlich Surgery, Wolhusen, Switzerland), a porcine collagen type I/III matrix, was placed and fixed with synthetic fibrin glue (Tisseel®, Baxter, Baxter, USA) along the lesion edges. The Hintermann™ spreader was then removed and matrix stability within a normal ankle range of motion was verified.

All clinical assessments were performed by a clinician who was blinded to the type of surgery. Each patient was evaluated preoperatively (T_0), as well as at 6 (T_1), 12 (T_2), and 24 (T_3) months. The evaluation included clinical and quality of life parameters. Clinical evaluation consisted of subjective global pain assessment by the VAS pain score, while the intensity of pain, walking capacity, and activities of daily life were assessed by the AOFAS score and SF-12 in its Physical (PCS) and Mental component score (MCS) [17–19].

MRI and CT-scan evaluations were also performed at T_0, T_1, T_2, and T_3. The area of the lesions was defined and measured for each patient on the MRI and CT-scan according to Choi et al. [7] using coronal length (horizontal extension measured from the coronal image), sagittal length (horizontal extension measured from the sagittal image), depth (vertical extension measured from the sagittal image) and area (calculated with the ellipse formula as coronal length × sagittal length × 0.79). All imaging measurements were made using the standard tools of the institution's Picture Archiving and Communication System (PACS). The reading of all MRI and CT-scans was blinded and was performed by two orthopaedic surgeons not involved in the surgical procedure.

3. Statistical analysis

The statistical analysis was performed by Matlab statistical toolbox version 2008 (MathWorks, Natick, MA, USA) for Windows at 32 bit, on a sample of 37 patients, 40.54% females and 59.46% males, with ages at operation into range 14–61, with mean around 34 years old and standard deviation (SD) around 12 years old multi-comparison tests were performed with ANOVA test for repeated measures into groups (Total group, GNE group, GE group) and the Bonferroni correction of p-value was used in pairwise comparison into groups, ANOVA one way was used to test the difference between the means of GNE group and GE group, and Student's t-test was used to test the difference between the means into group and evaluation significant trend. Finally univariate linear correlation analysis was performed and Pearson's linear correlation coefficient R were evaluated and the correspondent p-values were computed with T-Student test, under null hypothesis of Pearson's linear correlation coefficient $R = 0$. All statistical tests with p-value < 0.05 were considered as significant and all results were expressed as mean ± standard deviation (SD). For simplicity we denoted with T_0 = pre-operation control point, T_1 = six months post-operation, T_2 = six months post-operation and T_3 = twenty four months post-operation.

4. Results

Of 42 patients screened for eligibility, 37 satisfied the inclusion and exclusion criteria and were enrolled in the study. Of the 5 excluded patients, 3 had already been subjected to interventions to the affected ankle, 2 patients had severe post-traumatic osteoarthritis of the ankle. Each patient, in both groups was evaluated clinically and radiologically at T_0, T_1, T_2, and T_3. Patients satisfying the inclusion and exclusion criteria were divided into two groups. The sample of 37 patients was composed of 15 (40.54%) females and 22 (59.46%) males with ages at operation into range 14–61, with mean around 34 years old (SD ± 12). The GNE was composed of 24 patients, of which 10 (41.67%) were females and 14 (58.33%) males, mean age at surgery was 31 years old (range: 16–55, SD ± 10). The GE was composed of 13 patients, of which 5 (38.46%) were females and 8 (61.54%) males, mean age at surgery was 38 years old (range: 14–61, SD ± 15).

In GNE 8 lesions were centromedial, 7 posteromedial, 5 centrolateral, 2 anteromedial, 1 posterolateral and 1 centrocentral. In GE lesions were divided as follows: 8 centromedial, 3 centrolateral and 2 posteromedial.

No patients were lost to the final follow-up of 24 months.

4.1. Clinical evaluation

In both groups we found a significant difference for AOFAS, VAS, PCS and MCS with ANOVA for repeated measures through four time points ($p < 0.001$). In particular in the GNE, AOFAS improved significantly at each follow-up (T_0 vs T_1: $p = 0.0016$; T_1 vs T_2: $p = 0.0021$, T_2 vs T_3: $p = 0.0168$), VAS improved significantly between T_0 and T_1 ($p < 0.0001$) and between T_1 and T_2 ($p = 0.0039$), while PCS and MCS improved significantly only between T_0 and T_1 ($p < 0.0001$).

In GE we noted a significant improvement for AOFAS only between T_0 and T_1 ($p = 0.0017$) and between T2 and T_3 ($p = 0.0092$), VAS improved significantly between T_0 and T_1 ($p = 0.0035$) and

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