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MR-arthrography assessment after repair of chronic meniscal tears

Dragos Popescu · Sergi Sastre · Ana Isabel Garcia · Xavier Tomas · Diego Reategui · Miguel Caballero

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Abstract
Purpose The aims of this study were to assess the healing rate of repair of chronically torn meniscal tear with MR-arthrography and to evaluate the relationship between the clinical and the radiographic outcomes and the impact of the meniscal section on healing.
Methods MR-arthrography was performed at a median of 10.5 months (range 6–55) after surgery in 28 patients and healing assessed using Henning's criteria. All lesions were chronic (>3 months). Repairs were carried out at a median 14 months (range 6–80) from initial diagnosis. Eleven patients (39 %) had ACL ligament reconstruction as well. All lesions were located in the red or red–white zone. Patients were followed for a median of 18.5 months (range 8–68). Functional outcomes were evaluated using Barrett's healing criteria, Lysholm and Tegner score pre- and postoperatively.
Results Clinical healing of the lesion according to Barrett's criteria was achieved in 24 patients (85.7 %). Both Lysholm and Tegner scores improved significantly after the surgery ($p < 0.05$). According to Henning's criteria, 15 of the menisci healed completely (53.5 %), 10 partially (35.7 %) and 3 failed (10.8 %). There was no significant difference between the healing process in the posterior horn and the body of the meniscus (n.s.). No correlation was found between the healing results and the clinical scores. ACL reconstruction did not influence the healing process (n.s.). Patients waiting more than 1 year from lesion to surgery seem to have a higher rate of failure ($p = 0.02$).
Conclusions The results found suggest good short-term clinical and anatomic outcomes post-repair of meniscal lesions, despite their chronic nature. Longer waiting times may have negative effects on the healing process. Partial healing occurred often, but the meniscus was painless and stable.
Level of evidence Retrospective case series, Level IV.

Keywords Meniscal repair · Chronic meniscal lesion · Meniscal suture · Arthrography · Henning criteria

Introduction

Meniscectomy is known to have negative effects on the underlying articular cartilage [10, 26] so consequently, preserving the meniscus is one of the priorities of meniscal surgery. Meniscal suture performed with aim of preserving the meniscus and reducing the meniscal symptomatology has been reported to lead to good medium to long-term clinical outcomes in 70–90 % of cases [9, 18, 30]. However, not all meniscal lesions can be repaired, with one point of controversy being the outcome in the case of chronic lesions [21]. In fact, very few studies have examined outcomes following the repair of a chronic lesion [27, 28], and there is hardly any research examining the healing process of these lesions after repair. Most of the studies which have been published are retrospective; according to

D. Popescu (✉) · S. Sastre · D. Reategui
Knee Unit, Department of Orthopedic and Trauma Surgery, Hospital Clínic, C/Villarroel 170, 08036 Barcelona, Spain
e-mail: popescu@clinic.ub.es

A. I. Garcia · X. Tomas
Radiology Department, Hospital Clínic, Barcelona, Spain

M. Caballero
Surgery Department, IDIBAPS, University of Barcelona, Barcelona, Spain

Henning's healing rate [15], the reported partial and complete healing rate varies between 42 and 75 % [1, 16, 17, 32]. There is a discrepancy between clinical and radiographic healing results. In light of this, the aim of the present study was to assess the extent to which chronic meniscal lesions heal. In addition, we determined whether there were different healing rates for arthroscopic meniscal repair with respect to the different sections of the meniscus, and also if there was a correlation between the clinical and the radiographic healing outcomes.

Our hypothesis was that the complete healing rate in chronic meniscal tears will be inferior than the satisfactory clinical outcomes. A correlation between the clinical and radiographic findings was expected.

Materials and methods

Between January 2006 and December 2010, a total of 54 meniscal repairs in 53 patients were performed in our hospital. None of the patients were involved in competitive sports. Acute lesions (<3 months) were excluded from the study analysis, although due to the characteristics of our institution (i.e. a public hospital with long waiting lists), this accounted only for eight cases. All patients had meniscal symptoms (joint line tenderness, positive McMurray test ± locking) prior to surgery. No surgery was carried out in asymptomatic patients with a positive MRI signal. Inclusion criteria were as follows: longitudinal tear along the entire depth of the meniscus of at least 1 cm in length, location in the red zone or red/white zone of the meniscus (<6 mm from the periphery), no signs of meniscal degeneration and age <50 years. Patients with meniscal degeneration, radial rupture, multiple bucket-handle tears, intrameniscal tear or associated grade IV diffuse cartilage lesion were excluded. Complete ACL tears were reconstructed during the same surgical intervention and were not an exclusion criterion. All patients requiring ACL reconstruction had meniscal symptoms in addition to signs of clinical instability (positive Lachman's test, anterior drawer or pivot-shift). Of the 46 patients with chronic lesions (>3 months), six patients were excluded for concomitant procedures that we thought that could interfere with the outcomes: one patient had a simultaneous osteotomy performed and five patients had a cartilage repair procedure (one patient an ACI and four patients microfracture). Five more patients were lost for follow-up. Of the remaining 35 patients, it was possible to perform an MR-arthrography at least 6 months after surgery in 28 cases. Since the aim of the study was to assess the healing process, we included in the study only these 28 patients.

Surgical procedure

All the interventions were performed by two surgeons. After assessing the lesion, meniscal abrasion was meticulously carried out with a shaver and a basket punch. Repairs for lesions located in the posterior horn or rear part of the body were performed using FastFix® devices (Smith & Nephew Endoscopy, Andover, Massachusetts). Repairs in the rest of the body of the meniscus were performed with outside-in sutures using nonabsorbable no. 2/0 sutures. All of the FastFix® repairs were horizontal or oblique sutures. In the case of an associated ACL tear, an anatomic reconstruction was performed with the autologous hamstring tendons.

During the immediate postoperative period, isometric exercises were carried out and an orthosis was placed on the patient to limit the flexion to 60° during the first 3 weeks, as well as allowing partial axial load bearing with the use of crutches. After the third week, the flexion limit was raised to 110° and full weight bearing was allowed.

Assessments

All postoperative clinical assessments for meniscal healing were done by one independent surgeon using Barrett's criteria [3]. No test–retest reliability measurement was considered to be necessary. A meniscal tear is considered to be healed when none of the following signs are present: pain at the interarticular line, joint effusion, locking or a positive meniscal test. In all patients, the meniscal tear was diagnosed preoperatively by clinical examination and then confirmed via magnetic resonance imaging (MRI). Tegner and Lysholm functional scales [33] were used during both the preoperative period and the follow-up. We also evaluated the patients' degree of satisfaction by means of an arbitrary scale (1—unsatisfied, 2—more or less satisfied, 3—satisfied) and also considered the extent to which they returned to previous levels of activity.

Postoperative magnetic resonance arthrography (MRA)

All 28 patients underwent MR imaging of the postoperative knee in the coronal, transverse and sagittal planes with 1.5-T MR systems (Symphony, Siemens Medical Systems, Erlangen, Germany). Symphony protocols were as follows: sagittal turbo spin-echo PD-weighted (3,830/76, echo train length of seven), sagittal fat-saturated spin-echo T1-weighted (1,800/12), coronal spin-echo T1-weighted (repetition time ms/echo time ms of 749/10, echo train length of three), coronal fat-saturated turbo spin-echo DP-weighted (3,950/51), coronal gradient-echo DESS 3D and axial fat-saturated turbo spin-echo DP-weighted. Section thickness was 3 mm, except in the case of the coronal

DESS 3D sequence, were section thickness was 1 mm. An extremity coil was used.

MR-arthrography was performed with a mixture of 5 ml of iopromide dilute iodinated contrast (Ultravist 240 mg/ml; Bayer Laboratories, Berlin, Germany) and 10 ml saline mixture (hereafter, contrast mixture), with a concentration of 0.1 ml of gadobutrol (Gadovist 1.0 mmol/ml; Bayer Schering Pharma AG Laboratories, Berlin, Germany). After the intraarticular injection, the knees were gently flexed and extended for at least 20 times and stressed vigorously in varus and valgus to force contrast into the tear. All postoperative MR arthrograms images were interpreted prospectively by one musculoskeletal radiologist, in order to avoid intra- and interobserver variability. Imaging findings were mainly focused on the meniscus; meniscal tear in the presurgical lesion or in a new area was considered an abnormal communication of the contrast mixture from the joint into the substance of the meniscus, or as a displaced fragment, or an irregularly truncated meniscus. Additional MRI findings such as ligaments tears or osteochondral defects were also recorded.

The healing process was classified according to Henning's criteria, this corresponding to healing in the thickness of the meniscus. A meniscus was considered healed if it was healed over the full thickness of the tear. A tear was classed as incomplete healing if it was healed over at least 50 % of the thickness of the tear. A failure was defined as healing <50 % of the thickness at any point along the length of the tear. The healing rate was quantified as percentage. We calculated both the overall healing rate and that by segments (posterior, middle, anterior segment). If a failure (<50 % of the thickness) was present in more than two sections, this was considered a failure of repair in that segment. The healing process was finally correlated with demographic parameters (sex, laterality, age, meniscal type—lateral or medial), ACL reconstruction and meniscal segment.

Statistical analysis

The statistical analysis was performed using SPSS v16.0 for Windows (SPSS Inc., Chicago, IL, USA). Both the Tegner score and the Lysholm Activity Scale were normally distributed [Shapiro–Wilk test; p (0.05)]. The Student–Fisher method was used for the comparison of quantitative and qualitative variables, while the chi-squared test was used for qualitative variables. The level of significance was set at 0.05.

Results

Twenty-eight patients underwent an MRA in order to assess the healing process. There were 22 men and 6 women with a median age of 33 years (range 16–43). The median time between injury and surgery was 14 months (range 6–80). There were 19 medial meniscus and 9 lateral ones. Nineteen lesions were located in the posterior horn only, 1 was located in the body of the meniscus only and 8 were located in both areas. In 11 cases (39 %), a simultaneous autologous ACL reconstruction was performed. The median number of sutures or devices needed was 2 (range 1–5).

With a median follow-up of 18.5 months (range 8–68), a clinically healed meniscus was achieved in 24 patients (85.7 %), according to Barrett's criteria. The Lysholm score improved from a preoperative median value of 55.5 (range 12–86) to 95 (range 72–100) ($p < 0.05$). The Tegner score also improved from a median of 3.5 (range 0–8) to 6 (range 3–9) ($p < 0.05$). Twenty-six patients were satisfied after the surgery, 1 was less satisfied and 1 patient was unsatisfied. Twenty patients returned to previous levels of activity.

Radiographic healing outcomes

MR-arthrography was performed at a median time of 10.5 months (range 6–55) after the surgery. According to Henning's criteria, the overall healing rate was complete in 53.5 % of cases (15 patients), partial in 35.7 % (10 patients) and a failure in 10.8 % (3 patients) (see Table 1).

The healing rate in the posterior horn alone was complete in 51.9 % of cases (14 patients), partial in 37 % (10 patients) and a failure in 11.1 % (3 patients). As for the healing rate in the body of the meniscus, this was complete in 33.3 % of cases (3 patients), partial in 44.5 % (4 patients) and a failure in 22.2 % (2 patients). Although the healing rate appears to be worse in the body of the meniscus, this difference was not statistically significant (n.s.) (see Table 1).

All failures occurred in patients older than 40 years, but this fact was not statistically significant (n.s.) (Fig. 1). No other demographic parameter (sex, laterality, meniscal type—lateral or medial) was found to be correlated with the healing process (see Table 2). Neither was there a correlation between ACL reconstruction and the healing process (n.s.) (see Table 3).

Two of the three failures occurred in patients who waited more than 1 year for the surgery (see Table 4), suggesting a correlation between the time from lesion to surgery and the healing process ($p = 0.02$): the longer the waiting time the worse the outcome (Fig. 2), this being the case for both the overall rate and the rate by subgroup. No correlation was found between healing outcomes and clinical scores, Barrett's criteria, patient's satisfaction or the return to previous level of activity. Despite failure of the repair in three patients, this was not accompanied by

Table 1 Healing rates: overall and by meniscus segment

	Failure	Partial healing	Complete healing	Total
Posterior segment	3	10	14	27
Middle segment	2	4	3	9
Overall	3	10	15	28

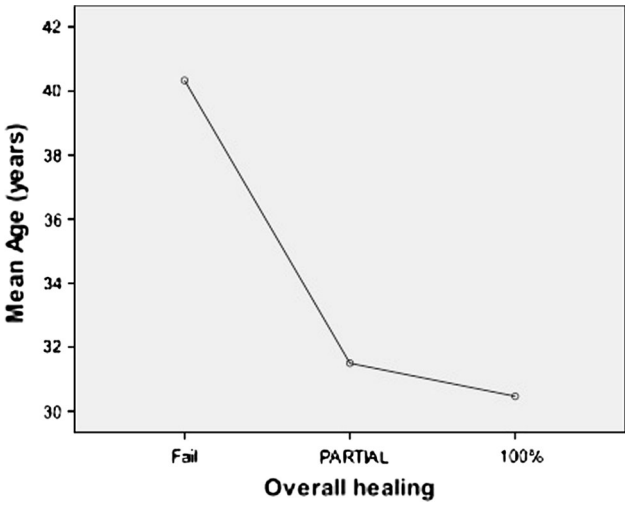

Fig. 1 Healing outcomes according to the age of the patient

Table 2 Healing outcomes by laterality of the meniscus

	Failure	Partial healing	Complete healing	Total
Medial meniscus	3	6	10	19
Lateral meniscus	0	4	5	9

There is no statistically significant difference in failure rate ($p = 0.42$)

worse clinical data. No additional procedure (meniscectomy) was necessary.

Discussion

The most important finding of this study was that chronic meniscal lesions do heal after the repair. In our opinion, the selection criteria are crucial to achieve a good result: good tissue with no degeneration of the menisci, location in the red or red–white zone and of course the type of patient, a low-demand one may have a protective effect in time on the lesion, both between injury and surgery and in the postoperative period. The removal of the scar tissue at the

Table 3 Healing outcomes according to the ACL status

	Failure	Partial healing	Complete healing	Total
ACL reconstructed	2	4	5	11
ACL stable	1	6	10	17

tear site and meniscal abrasion, coupled with a good fixation by means of nonabsorbable sutures or devices, are equally important for healing. There is scant literature dealing exclusively with the repair of chronic lesions, although the reported clinical outcomes, while heterogeneous, do not appear to differ from those of acute lesions [4, 19, 27, 28]. However, we found no study that focused on the healing of these lesions. In fact, most reports on healing concern revisions with second-look arthroscopy [1, 16, 17]. In a recent study using a CT-arthrography assessment, Pujol et al. [29] assessed 53 suture procedures (mostly acute) and found complete healing in 58 % of cases. Although their overall results are similar to ours, there are certain differences between the studies. In their study, the time between the onset of meniscal symptoms and repair did not have a statistically significant effect on meniscal healing, which may be explained by the much shorter waiting time in their study compared to ours (mean time of 21 weeks and 18 months, respectively). They also reported worse outcomes in the posterior horn lesions alone than in those extending to the body, as well as a correlation between clinical scores (IKDC) and healing results. This could be due to the fact that their sample was larger (almost twice patients) and also that IKDC is a more complete subjective questionnaire than is the Lysholm score. Most second-look arthroscopy studies report a complete healing rate between 73 and 88 %, which is higher than the reported rate when using arthrographic control [1, 16, 17, 32]. This might be due to the subjectivity of arthroscopy compared to an arthrographic image. There is a mismatch between arthrographic and arthroscopic findings [29].

Partial healing was a frequent finding in our study (35.7 %), and other arthrographic studies have reported similar results. Morgan et al. [24] reported 84 % asymptomatic patients after meniscal repair. Of these, 65 % had healed completely and 19 % had healed incompletely, leaving a failure of 16 %. All failures remained symptomatic, while all healed and incompletely healed menisci were asymptomatic. Cannon and Vittori [5] found that 50 % of incompletely healed tears were asymptomatic at more than 6 months after surgery. In the study of Pujol et al., the rate of partial healing was 24 % and the authors concluded that partial healing occurred often, with a stable tear on a narrowed and painless meniscus. We found a higher partial healing rate, possibly due to the chronicity of

Table 4 Healing outcomes according to the waiting time between injury and surgery

Waiting time	Failure	Partial healing	Complete healing	Total
<1 year	1	7	15	23
>1 year	2	3	0	5
Overall	3	10	15	28

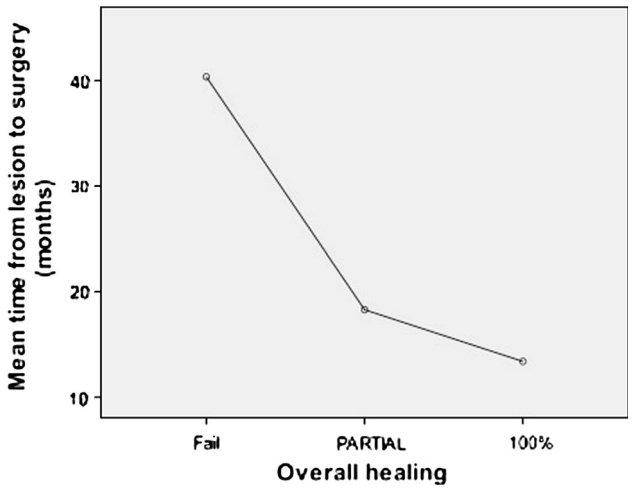

Fig. 2 Healing outcomes depending on the time between lesion and surgery

the lesion. Long-term follow-up is therefore needed to assess whether this has any clinical relevance over time.

The chronicity of lesions is a matter of controversy in two aspects. Firstly, there is no well-established cut-off point after which a lesion is regarded as chronic, with anywhere between 3 weeks and 3 months being used [4, 13, 19]. Secondly, published clinical outcomes are heterogeneous, and there is no clear consensus regarding the effect of waiting time on healing [8, 9, 27, 28]. It is also worth noting that we were unable to find any research evaluating the anatomic aspect of chronic lesion healing. In the present study, the waiting time between the lesion and surgery was of relevance for the healing process. Most of our patients had waited approximately 1 year for surgery, without this having any negative effect. However, a few patients had waited for 2 years or more, and in these cases, a direct relationship with suture failure was observed ($p = 0.01$). These data should be interpreted with caution due to the very small amount of patients who had waited more than 2 years. At all events, satisfactory healing was achieved when lesions were 'ideal' for suturing (i.e. vertical, peripheral, without degeneration) and when a correct surgical technique was used.

The beneficial effect of the ACL reconstruction in the same surgical procedure is controversial, although clinical outcomes seem to be better in ACL-reconstructed knees [3, 13, 24, 31]. Nepple et al. [25] in a recent meta-analysis for meniscal repair outcomes at greater than 5 years follow-up found a similar failure rate between intact and reconstructed ACL. We found no differences between stable and ACL-reconstructed knees. As we mentioned before, studies revising the healing process of the repaired menisci are scarce in the literature. Some of them, either arthrographic studies or second-look arthroscopy, found no differences between ACL-reconstructed and stable knees [17, 29, 37]. Kurosaka et al. [20] reported 13 failures in 111 meniscal repairs revised with second-look arthroscopy. 11 of them had an ACL reconstruction, and only one had a 5 mm side-to-side difference at KT-1000. 2 studies revised specifically the meniscal repair in ACL-reconstructed knee [1, 12]: they reported good healing results at second-look arthroscopies. On the other hand, lateral versus medial side effect also seems to be controversial: lateral meniscus sutures have better outcomes than medial ones [5]. In our study, we found no differences between medial and lateral sutures. No study revising the healing process reports better healing results in lateral meniscal repairs [11, 12, 17, 29]. It is not entirely clear whether or not the healing potential in the medial or lateral meniscus is different [25, 30].

To the best of our knowledge, only a few studies have used MR-arthrography for the assessment of meniscus healing [6, 23]. Many authors find that conventional MRI is unsuitable and unreliable for diagnosing the healing process of a repaired meniscus [2, 14]. Indeed, a nonspecific hypersignal may persist within the meniscal tear at 6 months or even later. Farley et al. [11] in a study comparing arthrography and MRI in the assessment of meniscal healing after repair found that T2-weighted fat-saturated MRI sequences had a sensitivity of 60 % and a specificity of 90 % whereas arthrography had a sensitivity and specificity of 90 %. They concluded that arthrography is necessary to demonstrate a retear in a previously repaired meniscus. In another study, Magee et al. [22] found that all the patients with meniscal repair required MR-arthrography to delineate whether there was a residual or recurrent meniscal tear. MR arthrograms demonstrated abnormal communication of the mixture into a meniscal repair, which indicates a residual or recurrent meniscal tear. Second-look arthroscopy was performed in all cases to confirm the meniscal tear. Several other studies have recommended the use of MR-arthrography over conventional MRI in repaired menisci [7, 35, 36]. A few studies have compared MR-arthrography with CT-arthrography. For example, Toms et al. [34] compared indirect MR-artrography with CT-arthrography for imaging of the postoperative meniscus. They found that CT-arthrography had the advantage of being quick and less susceptible to a variety of artefacts and concluded that it would likely be the investigation of choice if the clinical picture is clearly one

of a recurrent tear. By contrast, MR-arthrography was a better option for assessing the extra-articular soft tissue structures and bone marrow that would not be adequately imaged by CT-arthrography. Further comparative studies are needed to assess the accuracy of these arthrographic studies in the management of the repaired meniscus.

The present study has certain limitations. The number of patients is rather small, and this may affect the statistical power of some results, such as the correlation between clinical scores and the healing process. In some patients, outcomes were analysed at short-term follow-up. However, meniscal healing is supposed to be achieved at 6 months [2, 15], and the main goal of the study was to assess this aspect.

The satisfactory healing results are encouraging the idea of repair of meniscal tears, whenever is possible, despite its chronicity. Precise technique and good quality meniscal tissue are mandatory to achieve good outcomes.

Conclusion

Satisfactory healing results were achieved after repair of chronic meniscal tears. No differences were found between the different sections of the menisci or between the clinical and radiographic outcomes. Although partial healing is frequent, the meniscus in these cases is stable and painless. Long-term follow-up studies are required to elucidate whether repair of a chronically teared menisci protects the cartilage from degenerative changes or will retear in the future.

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