



Available online at
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com/en



Original article

Analysis of short and long-term results of horizontal meniscal tears in young adults



E. Sallé de Chou^{a,*}, N. Pujol^b, G. Rochcongar^a, T. Cucurulo^c, J.-F. Potel^d, F. Dalmay^e,
 F.-P. Ehkirch^f, C. Laporte^g, G. Le Henaff^h, R. Seilⁱ, C. Lutz^h, F.-X. Gunepin^j,
 B. Sonnery-Cottet^k, the Société Française d'Arthroscopie

^a Département d'orthopédie traumatologie, CHRU de Caen-Côte-de-Nacre, avenue de la Côte-de-Nacre, 14033 Caen, France

^b Centre hospitalier de Versailles, 177, rue de Versailles, 78150 Le Chesnay, France

^c 118, rue Jean-Mermoz, 13008 Marseille, France

^d Medipôle, 45, rue de Gironis, 31036 Toulouse, France

^e 2, rue du Docteur-Marcland, 87025 Limoges, France

^f Clinique Maussins-Nollet, 67, rue de Romainville, 75019 Paris, France

^g CHU de Rennes, 2, rue Henri-Le-Guilloux, 35033 Rennes, France

^h Clinique du Diaconat, 50, avenues des Vosges, 67000 Strasbourg, France

ⁱ Centre hospitalier de Luxembourg, 78, rue d'Eich, 1460 Luxembourg, Belgium

^j Clinique Mutualiste, 3, rue Robert-de-la-Croix, 56324 Lorient, France

^k Centre orthopédique Santy, 24, avenue Paul-Santy, 69008 Lyon, France

ARTICLE INFO

Article history:

Received 2 July 2015

Accepted 4 September 2015

Keywords:

Meniscus
 Meniscal repair
 Meniscal tear
 Meniscectomy
 Arthroscopy

ABSTRACT

Introduction: Symptomatic horizontal meniscal tears are rare but worrisome lesions in young adults. These are overuse injuries not amenable to the classic arthroscopic sutures. An open meniscal repair allows the meniscal lesion to be suture vertically, perpendicular to its in the vascularized zone. The purpose of this study was to evaluate the short and long-term clinical and radiological outcomes of the aforementioned surgical technique.

Material and method: The first cohort consisted of 24 patients operated between 2009 and 2011 (6 women, 18 men; mean age 26 years) having 11 lateral and 13 medial meniscal tears. The second cohort was of 10 patients operated between 2001 and 2002 (3 women, 7 men; mean age 24 years) having 8 lateral and 2 medial meniscal tears. Patients were reviewed at the last follow-up using the IKDC, Lysholm and KOOS scores. Patients in the first cohort had an MRI, while those in the second cohort had X-rays.

Results: Eighteen patients in the first cohort were reviewed with a mean follow-up of 2 years (12–45 months) and 9 patients from the second cohort were reviewed after 10 years (97–142 months). In the first cohort, one patient required secondary meniscectomy. The mean Lysholm score was 90 and the subjective IKDC was 85. Every MRI examination found reduced extent and intensity of the hyperintense signal. In the second cohort, no patients required secondary meniscectomy. Two patients had joint space narrowing (less than 50%) on radiographs. The mean Lysholm score was 99 and the subjective IKDC was 91.

Conclusion: Open repair of horizontal meniscal tears in young adults leads to good subjective and objective results in the short term, which are maintained in the long-term.

Level of evidence: Level IV – retrospective study.

© 2015 Published by Elsevier Masson SAS.

1. Introduction

Symptomatic meniscal tears are treated conservatively initially, while meniscectomy or meniscal repair are performed if conservative treatment fails [1]. Preserving as much meniscal tissue as possible is the primary concern [2], so as to prevent osteoarthritis (OA), which occurs in 19% of cases 13 years after total meniscectomy and in 36% of cases 30 years later [3,4]. The clinical outcomes

* Corresponding author.

E-mail address: salletedchou.etienne@neuf.fr (E. Sallé de Chou).

Table 1
Preoperative data for both patient cohorts.

	Number of patients	Mean age	Sex	Average follow-up	Time from symptoms to surgery	Lateral meniscus (n)	Medial meniscus (n)	Cyst (n)	Side
Cohort 1 Short-term	24	26 years	6 W/18 M	2 years (12–45)	14 months (6–13)	11	13	14	12R/12L
Cohort 2 Long-term	10	24 years	3 W/7 M	10 years (97–142)	23 months (6–90)	2	8	3	5R/5L

L: left, M: men, R: right, W: women.

are better and OA progression is less when the meniscus is repaired than when it is partially resected [5].

Horizontal cleavage tears in young adults were first described by Biedert in 1993 [6]. These injuries are graded on a scale of 1 to 3 based on MRI images [7]. They make up 20–23% of symptomatic meniscal lesions [8,9]. The etiology of these lesions has not been defined. They are not the result of specific trauma causing vertical tears nor are they degenerative lesions in young, non-arthritis patients. A synovial cyst is usually present at the same time. More than half of patients who have a meniscal cyst also have a horizontal cleavage tear [10,11]. Several treatments have been proposed: conservative treatment alone, arthroscopic suturing with or without fibrin clot, partial meniscectomy [12,13], arthroscopic partial meniscectomy of the inferior flap [14] and open suture repair [15].

Repair of fresh traumatic vertical meniscal tears results in good outcomes [1,16]. Repair of horizontal tears so as to preserve as much meniscal tissue as possible can be contemplated, as long as it is effective in the short term (pain, return to sports) and long term (low reoperation and OA rate). The purpose of this study was to evaluate the survival of suture repairs performed for horizontal cleavage tears in the meniscus of young adults and to review the short- and long-term clinical and radiological outcomes. We hypothesized that function would improved quickly and permanently, the hyperintense MRI signal would be reduced early on and the rate of OA on radiographs would be low in the long term.

2. Material and methods

This was a retrospective, multicentre study of two patient cohorts reviewed at different times. All patients had meniscal pain for at least 6 months that did not respond to conservative treatment and that forced them to stop their sports activities. All patients were operated on, either by open suturing after arthroscopy or by arthroscopic suturing.

2.1. First cohort

Twenty-four patients with a minimum follow-up of 12 months. All had normal preoperative radiographs, without signs of OA. The mean age at the time of the procedure was 27 ± 9 years (13–40 years). There were 6 women and 18 men; an equal number of left and right knees were affected. Fourteen patients (58%) also had a meniscal cyst. Six patients had a medial meniscus tear and 18 patients had a lateral meniscus tear. All knees were stable, without associated ligament damage. The symptoms had been present for a mean of 14 months (6–36 months) before surgery. Seventeen patients underwent open suture repair and seven patients had an all-inside repair. After a mean follow-up of 25 ± 11 months (12–45 months), these patients underwent an MRI examination to evaluate meniscal healing and the meniscal signal. Objective and subjective outcomes were evaluated using the KOOS, Lysholm and subjective IKDC questionnaires; the level of return to sport was recorded, as was the range of motion.

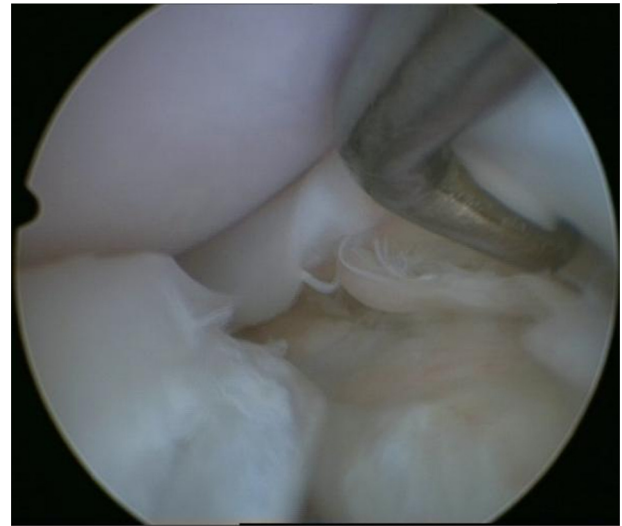


Fig. 1. Horizontal cleavage tear with unstable flap.

2.2. Second cohort

Ten patients with a minimum follow-up of 10 years. All had normal preoperative radiographs, without signs of OA. The mean age at the time of the procedure was 24 ± 11 years (14–45 years). There were 3 women and 7 men; an equal number of left and right knees were affected. Three patients also had a meniscal cyst. Eight patients had a medial meniscus tear and two patients had a lateral meniscus tear. All knees were stable, without associated ligament damage. The symptoms had been present for a mean of 23 months (6–90 months) before surgery. All of these patients were treated by open suture repair. After a mean follow-up of 10 ± 1.25 years (97–142 months), these patients underwent anteroposterior, lateral, schuss and sunrise radiographs that were interpreted using Ahlbäck's classification system [17]. Objective and subjective outcomes were evaluated using the KOOS, Lysholm and subjective IKDC questionnaires; the level of return to sport was recorded, as was the range of motion.

The two groups were comparable in terms of standard preoperative data ($P > 0.05$), except for the duration of symptoms and delay before surgery ($P = 0.0057$) (Table 1). Arthroscopy was performed in all cases. Grade 2 lesions were normal during arthroscopic exploration, while grade 3 cases had a horizontal tear. If an unstable meniscal flap was present, a minimal partial meniscectomy was performed (Fig. 1). When the open repair was performed, retroligamentous arthrotomy was used to address the lesions. If a meniscal cyst was present, it was excised through the incision. Vertical meniscus and synovium detachment was carried out so that an abrasive hook could be used to stimulate the injured area. The tear was repaired with PDS 0 by placing single vertical sutures (5 ± 1 points in the first cohort and 4 ± 1 in the second) perpendicular to the tear (Fig. 2).

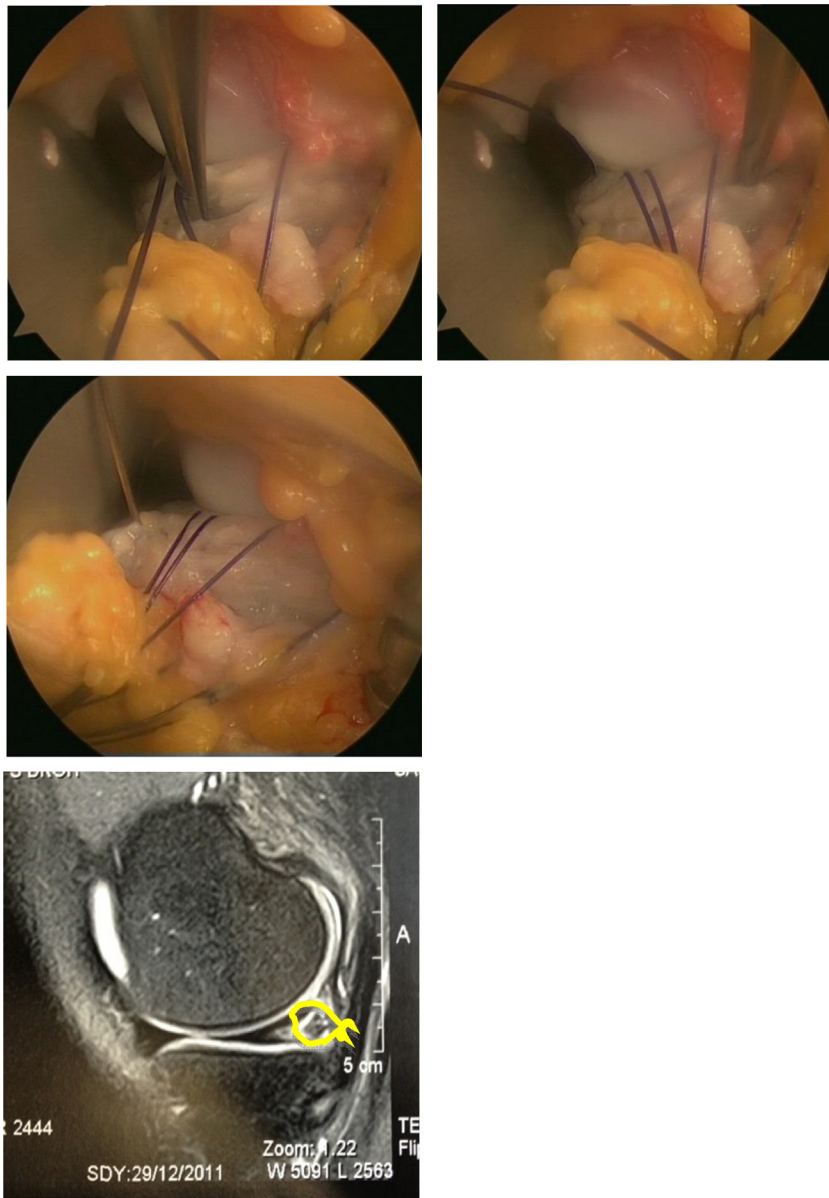


Fig. 2. View of horizontal tear, vertical sutures placed perpendicular to lesion.

In the first cohort, the postoperative MRI images were read by three surgeons using a reading grid developed for the study, in order to grade the type of image found. Type I was a complete absence of intrameniscal hyperintense signal; type II was a hyperintense signal at the free edge that did not reach the meniscal wall; type III was the presence of hyperintensity at the meniscal wall (Table 2, Figs. 3–5).

Both groups had the same postoperative course. Gradual, protected weight-bearing was allowed using two crutches and patients wore a knee splint for 1 month. During rehabilitation, knee flexion

Table 2
Grid used by surgeons to read MRI images after 2 years' follow-up.

Type I	No intrameniscal hyperintensity
Type II	Hyperintensity in avascular zone that does not reach meniscal wall
Type III	Hyperintensity that includes the meniscal wall

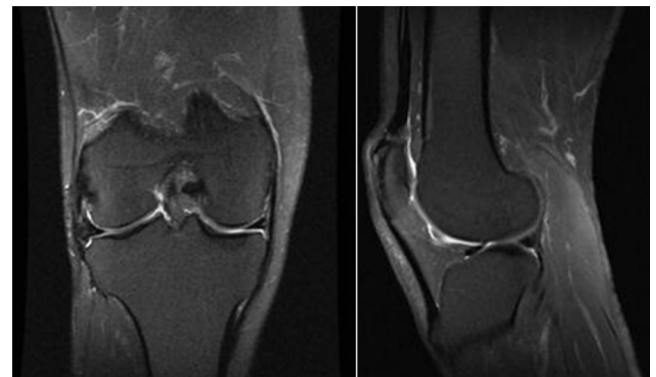


Fig. 3. Type I images on MRI; patient treated for lesions in the middle and posterior segments of the lateral meniscus.

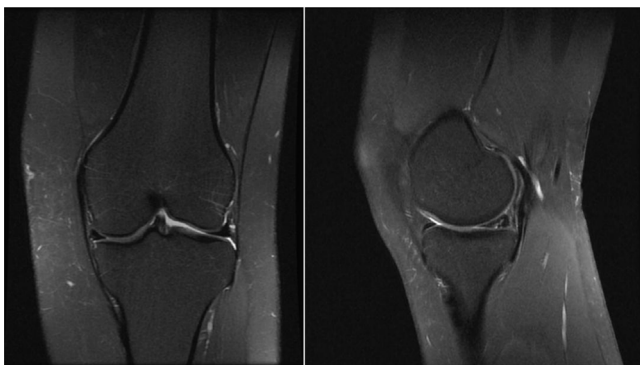


Fig. 4. Type II images on MRI; patient treated for lesions in the middle and posterior segments of the medial meniscus.

was limited to 90° during the first month. Return to pivot sports was allowed after 6 months.

3. Results

3.1. First cohort (short term)

Eighteen patients were reviewed after a mean of 25 ± 11 months, which is 75% of the original cohort. Partial meniscectomy was performed in 17 cases before the meniscal repair. At the last follow-up, range of motion was normal and symmetric for all patients. Thirteen patients underwent follow-up MRI examination. All had resumed their sports participation, with 16 of them (88.8%) returning to their pre-injury level. The mean subjective IKDC score was 85 ± 13. The mean KOOS score items were 93 ± 8 for pain, 90 ± 10 for symptoms, 97 ± 4 for function, 87 ± 15 for sports activities and 78 ± 14 quality of life (Fig. 6). The mean Lysholm score was 90 ± 9.

On MRI, 10 of the 13 patients still had an intrameniscal hyperintense signal. Three patients no longer had any hyperintensity (23%) (Fig. 7). All of these patients had a preoperative grade 3 lesion. Five patients had hyperintensity in the free edge only (38.5%); four of them had a preoperative grade 3 lesion and one had a grade 2 lesion. Five patients had hyperintensity in the meniscal wall (38.5%); four of them had a preoperative grade 3 lesion and one had a grade 2 lesion. In all cases, the hyperintense signal was reduced in intensity and extent relative to the preoperative images. There was a slight difference between a strong hyperintensity (white, same intensity as fluid) and weak hyperintensity (grey, same intensity as cartilage in T2-weighted and fat-saturated sequences) (Fig. 8). There were no significant differences in terms of the functional outcomes for the



Fig. 5. Type III images on MRI; patient treated for lesions in the middle and posterior segments of the lateral meniscus.

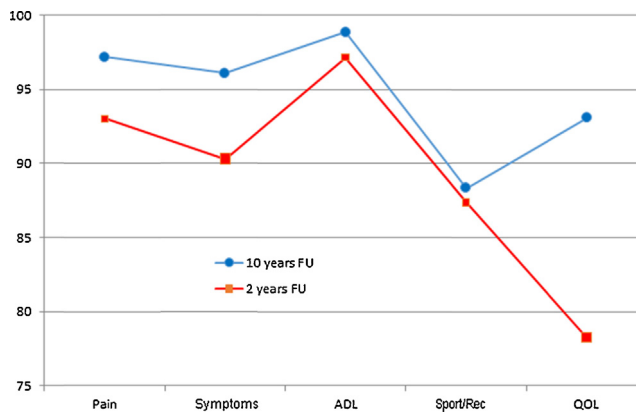


Fig. 6. KOOS functional scores at 2 and 10 years.

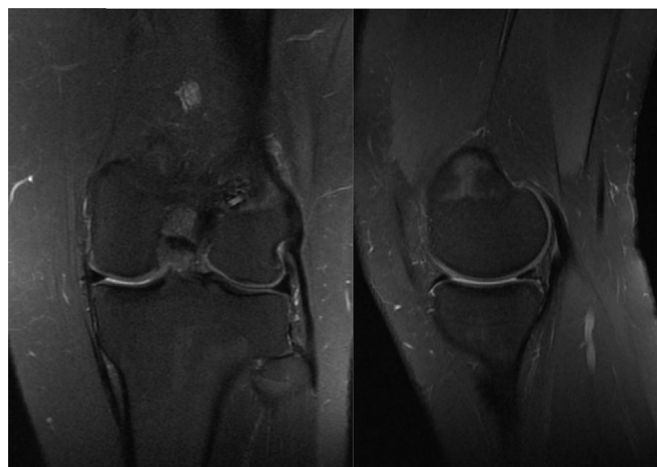


Fig. 7. MRI of a patient, 2 years after repair in the body and posterior horn of the lateral meniscus (grade 3 lesion).

various types of MRI images found ($P > 0.05$) (Table 3). The cyst did not reappear on MRI in the nine patients with preoperative cysts.

There were no significant differences ($P > 0.05$) in the subjective IKDC and Lysholm scores between medial or lateral meniscus injuries, grade 2 or grade 3 lesions, and patients with or without a cyst (Table 4). There were three complications: one patient suffered septic arthritis and required arthroscopic joint lavage with 6 weeks of antibiotics coverage; one patient suffered a deep venous thrombosis; one patient underwent partial meniscectomy because of persistent pain.

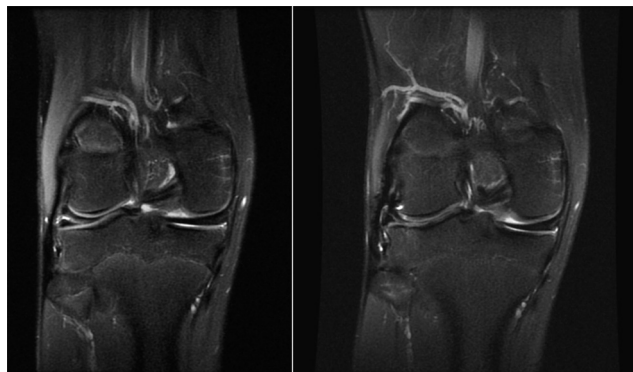


Fig. 8. Preoperative and 2-year postoperative MRI for the same patient; persistence of a grey, hyperintense signal (type III).

Table 3
Functional outcomes by MRI grade at the last follow-up.

MRI grade	Number of patients	Postop subjective IKDC	KOOS					Postop Lysholm
			Postop pain	Postop symptoms	Postop daily life	Postop sports	Postop quality of life	
I	3	83.9	94.4	96.5	95.1	85	75	91.3
II	5	83.4	92.9	91.2	97	85	74.9	87.4
III	5	84.6	88.8	83.5	96.4	84	75	87.6
P	0.74	0.70	0.87	0.75	0.73	0.74	0.70	

Table 4
Functional outcome scores by involved side, lesion severity and cyst presence.

Cohort 1 (short term)	n	IKDC	Lysholm
Medial meniscus	7	87 ± 11	89 ± 10
Lateral meniscus	11	85 ± 5	91 ± 6
Grade 2 lesion	6	91 ± 7	93 ± 6
Grade 3 lesion	12	83 ± 15	89 ± 10
Cyst	12	87 ± 10	89 ± 10
No cyst	6	83 ± 20	93 ± 6

3.2. Second cohort (long term)

Seven patients were reviewed at the clinic and 2 were contacted by telephone to fill out the questionnaires; 1 patient was lost to follow-up. Two patients underwent partial meniscectomy before the repair. The average follow-up was 10 ± 1.25 years. No patient required secondary meniscectomy. All of the reviewed patients had returned to their pre-injury level of sports participation within the first 2 years' postoperative. Eight of the nine patients had symmetric range of motion (89%) and one patient had a 10° deficit relative to the contralateral side. The mean Lysholm at follow-up was 99.6 and the mean subjective IKDC score was 91.2 ± 9.6 . The mean KOOS score items were 97.2 ± 8.8 for pain, 96 ± 5 for symptoms, 98.8 ± 1.4 for daily activities, 88.3 ± 21.6 for sports activities and 93 ± 9.6 quality of life (Fig. 6). Five of the seven patients (71.4%) who had radiographs taken at the last follow-up had no signs of joint space narrowing. Two patients (28.6%) had less than 50% joint narrowing, which corresponds to Ahlbäck grade I. No complications or surgical revisions were recorded.

There was no significant difference between the two cohorts of patients in terms of subjective outcomes (Table 5). This suggests that the results were durable and did not deteriorate over time.

4. Discussion

The main conclusion of this study is that open meniscal repair of symptomatic horizontal meniscus tears in young adults leads to good results that are stable over time (up to 10 years). The overall failure rate of 3.7% (1/27) is similar to published data. The failure rate for repair of horizontal cleavage tears was found to be 21.4% in a systemic review [18]. It is also similar to the expected 13% failure rate after repair of vertical tears [19]. In a French Society of Arthroscopy (SFA) symposium in 2003, the rate of secondary meniscectomy was reported to be 23%, with three-quarters of them occurring within the first 2 years postoperative [20]. Despite the delay before surgery being different in our two patient cohorts, the functional outcomes were not significantly different. All of the

subjective scores (IKDC, Lysholm and KOOS) seemed to improve over time, but this clinical improvement was not significant.

Few published studies exist on the surgical treatment of horizontal cleavage tears of the meniscus in young athletes. The first study by Biedert in 2000 compared four different treatment for grade 2 lesions in 40 patients, who were reviewed 2 years later using the IKDC score [12]. The best outcomes were obtained with arthroscopic partial meniscectomy: 100% normal or satisfactory results. There were 90% normal or satisfactory results following arthroscopic suturing. Conservative treatment led to 75% normal results and partial meniscectomy with meniscal suturing after placement of a fibrin clot led to 43% normal results. Kim et al. reported on 40 cases of inframeniscal meniscectomy after 2 years; the outcomes were good, with a mean Lysholm score of 91 [14]. Kamimura and Kimura reported clinical improvement in nine patients who underwent arthroscopic suturing with an exogenous fibrin clot [13]. Pujol et al. found similar results to this study after 3 years with the same surgical technique [15].

Horizontal cleavage tears affect both the vascularized and non-vascularized portions of the meniscus. Since only the peripheral part of the meniscus is vascularized (10–25%) [21], healing can only be expected in the meniscal wall. Noyes reviewed 30 repairs of traumatic vertical meniscal tears in the avascular zone of stable knees and found good outcomes with 87% of patients being asymptomatic and not needing surgical revision after 3 years; three patients underwent secondary partial meniscectomy [22]. In our study, one patient required secondary meniscectomy at 1 year postoperative. Although these horizontal tears are different than the vertical tears studied by Noyes, both involved the avascular zone.

The intrameniscal hyperintense signal persisted 3 years postoperative in three-quarters of the subjects, with no recurrence of the cyst or poor subjective outcomes. We also found a slight difference in the signal intensity. A white hyperintense signal translates to fluid, and does not correspond anatomically to a grey hyperintense signal that shows an area of fibrous scar. The MRI images after 2 years also had hyperintense signals, but the extent and intensity had been reduced. Muellner observed hyperintensity after more than 12 years' follow-up in 15 of 19 patients who underwent meniscal repair [23]. Pujol et al. also found hyperintensity after 10 years' follow-up in 20 of 23 patients who underwent arthroscopic meniscal repair and had good functional outcomes [24].

The open surgical technique used in this study only addresses the lesion on the meniscal wall. More than 60% of patients had no hyperintensity in the meniscal wall on the 2-year postoperative MRI. Healing of meniscal tissue has previously been studied by computed tomography [20]. Complete healing was found in 39% of patients, partial healing in 34% and no healing in 27%.

Table 5
Functional outcome scores for the short- and long-term cohorts.

	n	IKDC	Lysholm	KOOS				
				Pain	Symptoms	Daily life	Sports	Quality of life
Cohort 1 Short-term	17	85.7	90.2	93	90.3	97.2	87.3	78.3
Cohort 2 Long-term	9	91.2	99.7	97.2	96	98.8	88.3	93.1
P		0.16	0.13	0.17	0.15	0.7	0.19	0.09

However, these imaging findings had no clinical consequences as good results persisted 10 years later. Zanetti et al. performed bilateral MRI examinations of 100 patients who had clinical signs of unilateral meniscal lesion. They found that 36% of asymptomatic knees had a meniscal lesion [25]. These findings demonstrate a lack of correlation between clinical outcomes and imaging. Unless an intra-articular loose body or locking is present, Englund et al. advocate conservative treatment first, saying that the meniscal lesion found on MRI is not necessarily the cause of the patient's pain [26]. In summary, a significant number of studies have found hyperintensity in the meniscus after repair of vertical or horizontal tears, in vascular and avascular areas, and in asymptomatic patients. There is no obvious correlation between these MRI images and the good, long-term radiographical and clinical outcomes after meniscal repair. One of the limitations of this study was the small number of subjects; this can be explained by the rarity of these lesions and the mobility of the young adult population.

5. Conclusion

In young adults with a symptomatic horizontal meniscus tear that is resistant to conservative treatment, open repair of the meniscal wall after arthroscopy leads to good clinical outcomes after 2 and 10 years of follow-up, with a low reoperation rate for secondary meniscectomy and a low rate of radiological OA after 10 years. When these initially complex tears are treated correctly, they are durably stabilized with no recurrence of symptoms, preservation of a functional meniscus and functional outcomes after 10 years. Open suture repair is recommended for this specific type of horizontal cleavage tear in young adults.

Disclosure of interest

B. Sonnery-Cottet is a consultant with Arthrex. The other authors declare that they have no conflicts of interest concerning this article.

References

- [1] Beaufils P, Hulet C, Dhénain M, Nizard R, Nourissat G, Pujol N. Clinical practice for the management of meniscal lesions and isolated lesions of the anterior cruciate ligament of the knee in adults. *Orthop Traumatol Surg Res* 2009;95:437–42.
- [2] Roos EM, Ostenberg A, Roos H, Ekdahl C, Lohmander LS. Long-term outcome of meniscectomy: symptoms, function, and performance tests in patients with or without radiographic osteoarthritis compared to matched controls. *Sweden Osteoarthritis Cartilage* 2001;9:316–24.
- [3] McNicholas MJ, Rowley DI, McGurty D, Adalberth T, Abdon P, Lindstrand A, et al. Total meniscectomy in adolescence. A thirty-year follow-up. *J Bone Joint Surg Br* 2000;82(2):217–21.
- [4] Hulet CH, Locker BG, Schiltz D, Texier A, Tallier E, Vielpeau CH. Arthroscopic medial meniscectomy on stable knees. *J Bone Joint Surg Br* 2001;83(1):29–32.
- [5] Paxton ES, Stock MV, Brophy RH. Meniscal repair versus partial meniscectomy: a systematic review comparing reoperation rates and clinical outcomes. *Arthroscopy* 2011;27(9):1275–88. <http://dx.doi.org/10.1016/j.arthro.2011.03.088> [Epub 2011 Aug 6].
- [6] Biedert RM. Intrasubstance meniscal tears. *Clinical aspects and the role of MRI. Arch Orthop Trauma Surg* 1993;112(3):142–7.
- [7] Crues JV, 3rd, Mink J, Levy TL, Lotysch M, Stoller DW. Meniscal tears of the knee: accuracy of MR imaging. *Radiology* 1987;164(2):445–8.
- [8] Dandy DJ. The arthroscopic anatomy of symptomatic meniscal lesions. *Bone Joint Surg Br* 1990;72(4):628–33.
- [9] Servien E, Acquitter Y, Hulet C, Seil R, French Arthroscopy Society. Lateral meniscus lesions on stable knee: a prospective multicenter study. *Orthop Traumatol Surg Res* 2009;95(8 Suppl. 1):S60–4. <http://dx.doi.org/10.1016/j.otsr.2009.09.003> [Epub 2009 Nov 5].
- [10] Hulet C, Souquet D, Alexandre P, Locker B, Beguin J, Vielpeau C. Arthroscopic treatment of 105 lateral meniscal cysts with 5-year average follow-up. *Arthroscopy* 2004;20(8):831–6.
- [11] Lu KH. Arthroscopic meniscal repair and needle aspiration for meniscal tear with meniscal cyst. *Arthroscopy* 2006;22(12):1367e1–4 [Epub 2006 Sep 11].
- [12] Biedert RM. Treatment of intrasubstance meniscal lesions: a randomized prospective study of four different methods. *Knee Surg Sports Traumatol Arthrosc* 2000;8(2):104–8.
- [13] Kamimura T, Kimura M. Repair of horizontal meniscal cleavage tears with exogenous fibrin clots. *Knee Surg Sports Traumatol Arthrosc* 2011;19(7):1154–7. <http://dx.doi.org/10.1007/s00167-011-1404-5> [Epub 2011 Feb 3].
- [14] Kim JM, Bin SI, Kim E. Inframeniscal portal for horizontal tears of the meniscus. *Arthroscopy* 2009;25(3):269–73. <http://dx.doi.org/10.1016/j.arthro.2008.09.025> [Epub 2008 Dec 5].
- [15] Pujol N, Bohu Y, Boisrenoult P, Macdes A, Beaufils P. Clinical outcomes of open meniscal repair of horizontal meniscal tears in young patients. *Knee Surg Sports Traumatol Arthrosc* 2013;21(7):1530–3.
- [16] Prise en charge thérapeutique des lésions méniscales et des lésions isolées du ligament croisé antérieur du genou chez l'adulte. HAS/Service des bonnes pratiques professionnelles; 2008.
- [17] Ahlbäck S. Osteoarthritis of the knee. A radiographic investigation. *Acta Radiol Diagn (Stockh)* 1968;277:7–72.
- [18] Kurzweil PR1, Lynch NM2, Coleman S3, Kearney B4. Repair of horizontal meniscus tears: a systematic review. *Arthroscopy* 2014;30(11):1513–9. <http://dx.doi.org/10.1016/j.arthro.2014.05.038>.
- [19] Pujol N, Tardy N, Boisrenoult P, Beaufils P. Long-term outcomes of all-inside meniscal repair. *Knee Surg Sports Traumatol Arthrosc* 2015;23(1):219–24.
- [20] Beaufils P, Cassard X. Meniscal repair – SFA 2003. *Rev Chir Orthop Reparatrice Appar Mot* 2007;93(8 Suppl.), 5S12–3.
- [21] Arnoczky SP, Warren RF. Microvasculature of the human meniscus. *Am J Sports Med* 1982;10(2):90–5.
- [22] Noyes F, Barber-Westin SD. Arthroscopic repair of meniscus tears extending into the avascular zone with or without anterior cruciate ligament reconstruction in patients 40 years of age and older. *Arthroscopy* 2000;16(8):822–9.
- [23] Muellner T, Egkher A, Nikolic A, Funovics M, Metz V. Open meniscal repair: clinical and magnetic resonance imaging findings after twelve years. *Am J Sports Med* 1999;27(1):16–20.
- [24] Pujol N, Tardy N, Boisrenoult P, Beaufils P. Magnetic resonance imaging is not suitable for interpretation of meniscal status ten years after arthroscopic repair. *Int Orthop* 2015;37(12):2371–6. <http://dx.doi.org/10.1007/s00264-013-2039-6>.
- [25] Zanetti M, Pfirrmann CW, Schmid MR, Romero J, Seifert B, Hodler J. Patients with suspected meniscal tears: prevalence of abnormalities seen on MRI of 100 symptomatic and 100 contralateral asymptomatic knees. *AJR Am J Roentgenol* 2003;181(3):635–41.
- [26] Englund M, Roemer FW, Hayashi D, Crema MD, Guermazi A. Meniscus pathology, osteoarthritis and the treatment controversy. *Nat Rev Rheumatol* 2012;8(7):412–9. <http://dx.doi.org/10.1038/nrrheum.2012.69>.