Orthopaedics & Traumatology: Surgery & Research 109 (2023) 103681

Contents lists available at ScienceDirect

Orthopaedics & Traumatology: Surgery & Research

journal homepage: www.elsevier.com

Original article

Medial meniscal repair in stable knees: Survival rate and risk factors for failure at a minimum of 5 years

Simon Pelletier[a,*], Azeddine Djebara[b], Benjamin Freychet[c], Olivier Carnessechi[d], Nicolas Graveleau[a], Marie-Laure Louis[e], Kevin Benad[f], Cesar Praz[g], Gaëlle Maroteau[h], Sammy Badr[h], Teddy Trouillez[i], Henri Favreau[j], Vincent Pineau[k], Sophie Putman[i,l], and The Francophone Arthroscopy Society (SFA)[m]

[a] *Clinique du sport de Bordeaux Merignac, 4, rue Georges-Negrevergne, 33700 Mérignac, France*
[b] *Service d'orthopédie et traumatologie, centre hospitalier de Versailles André-Mignot, 78150 Le Chesnay, France*
[c] *Centre orthopédique Santy, 24, avenue Paul-Santy, 69008 Lyon, France*
[d] *Centre Ortheo, 21, boulevard Karl-Marx, 42100 Saint-Étienne, France*
[e] *Institut de chirurgie orthopédique et sportive, clinique Juge, groupe Almaviva recherche, Marseille, France*
[f] *Nord Genou, 126, rue de la Louvière, Lille, France*
[g] *CHU de Caen, 14000 Caen, France*
[h] *Département universitaire de chirurgie orthopédique et de traumatologie, hôpital Roger-Salengro, rue Émile-Laine, 59037 Lille cedex, France*
[i] *Service de radiologie ostéoarticulaire, CHU de Lille, Lille, France*
[j] *Service d'orthopédie et de traumatologie, hôpital de Hautepierre, hôpitaux universitaires de Strasbourg, 67098 Strasbourg, France*
[k] *Clinique Médipole Garonne, Toulouse, France*
[l] *Metrics, université Lille-Nord de France, 59000 Lille, France*
[m] *15, rue Ampère, 92500 Rueil-Malmaison, France*

ARTICLE INFO

Article history:
Received 28 March 2023
Accepted 23 August 2023

Keywords:
Knee
Menisci
Suture
Arthroscopy
SFA
Symposium

ABSTRACT

Introduction: The menisci play a major role in the protection of the knee against osteoarthritis. A medial meniscus (MM) tear occurring in a stable knee is more at risk of repair failure than a suture concomitant with reconstruction of the anterior cruciate ligament.
Hypothesis: The survival of MM sutures in stable knees depends on the type of lesion.
Materials and methods: This retrospective study was carried out as part of the 2022 Francophone Arthroscopy Society's symposium, across 10 centers (Bordeaux-Mérignac, Caen, Lille, Lille Louvière, Lyon, Marseille, Toulouse, Saint-Étienne, Strasbourg and Versailles) including medial meniscus sutures in stable knees performed before the end of 2017 (minimum 5 years of follow-up) with a collection of demographic, imaging, suture and postoperative protocol data, and a functional evaluation using the Knee injury and Osteoarthritis Outcome score (KOOS). The aim of this study was to analyze the medial meniscus sutures in stable knees and to evaluate their survival and their risk factors for failure according to the type of lesion; failure being defined by the use of a meniscectomy.
Results: Three-hundred and sixty-seven MM sutures, including 122 bucket-handle tears, were included. The KOOS score was improved by the meniscal suture by an average of 22.2 points for each sub-score ($p < 0.05$), with an improvement, which was more marked for the bucket-handle tears. The failure rate, defined by revision surgery by meniscectomy, was 33% on average (42% for bucket-handles tears, 26% for others). The probability of survival was reduced for bucket-handle tears (62% at 5 years versus 77% for the other types). For all lesions, the main risk factor identified for failure was immediate weight-bearing [OR = 3.6 (1.62; 7.98), $p = 0.0016$]. Smoking was a failure risk factor for bucket-handle tears [OR = 5.76 (1.81; 18.35), $p = 0.003$].
Conclusion: MM sutures in stable knees improve knee function but present a different risk of failure depending on the type of lesion treated with a higher risk of failure for bucket-handle tears with the need for caution to be applied with regards to weight-bearing and smoking.
Level of evidence: IV; retrospective series.

© 2023 Published by Elsevier Masson SAS.

* Corresponding author.
E-mail address: pelletier-simon@orange.fr (S. Pelletier).

https://doi.org/10.1016/j.otsr.2023.103681
1877-0568/© 2023 Published by Elsevier Masson SAS.

1. Introduction

The menisci play a major role in load distribution, knee stability and osteoarthritis prevention [1]. Arthroscopic meniscal surgery has evolved enormously in recent years with a significant increase in the number of meniscal repairs at the expense of meniscectomies. [2,3] Many types of implants have emerged and the indications for meniscal repair have expanded [4,5].

In the long term, meniscal repairs provided better functional and radiological results than partial meniscectomies [6,7]. While modern techniques have made it possible to suture a large proportion of meniscal tears, the failure rate, generally occurring within a year, remains significant [8]. Certain risk factors for failure have already been highlighted, such as the type of lesion, the type of suture, the integrity of the collateral ligaments or even a suture of the medial meniscus (MM) compared to one of the lateral meniscus [9].

Indeed, a meniscal tear occurring in a stable knee is more at risk of repair failure than a suture concomitant with reconstruction of the anterior cruciate ligament [10]. It is also known that bucket-handle tears have a poorer prognosis than simple vertical tears, with a failure rate of around 30% [11].

It therefore becomes legitimate to ask the question of the place of meniscal repair in the event of a MM tear in a stable knee. In order to provide some answers, we carried out a retrospective, multicenter study during the symposium of the Francophone Arthroscopy Society in order to:

- report the long-term results of a MM suture in a stable knee, in terms of survival;
- analyze the results according to the type of meniscal lesion;
- research the risk factors for failure of these meniscal repairs.

The initial hypothesis was that the results after MM suturing in a stable knee depend on the type of lesion.

2. Material and method

A retrospective multicenter study was carried out across 10 French centers participating in the 2022 symposium of the Francophone Arthroscopy Society (Bordeaux-Mérignac, Caen, Lille, Lille Louvière, Lyon, Marseille, Toulouse, Saint-Étienne, Strasbourg and Versailles).

This retrospective series included patients operated on for a MM suture before the end of 2017 to have a minimum follow-up of 5 years during the symposium. The exclusion criteria were knees with a history of anterior cruciate ligament rupture, operated on or not.

Files with too much missing data or without sufficient follow-up were also excluded.

The demographic data of the patients were collected: age, sex, body mass index (BMI), smoking, initial trauma, and type of sport during the trauma, if applicable.

The preoperative imaging data included on the X-ray were the Hip Knee Ankle (HKA) axis measured on the long leg view, the α and β angles, the tibial slope and the presence or absence of osteoarthritis, as well as its severity [12–15].

Magnetic resonance imaging (MRI) data included the tibiofemoral angle, α and β angles, medial tibial slope, presence of chondral lesions and the associated International Cartilage Repair Society (ICRS) stage, type of meniscal tear and its area (1, 2 or 3 of the periphery from the center of the knee) [16,17].

The condition of the knee intraoperatively was assessed by the Knee injury and Osteoarthritis Outcome score (KOOS) [18], and the patient's activity was assessed by the Tegner score [19].

The intraoperative data included the type of suture, the number of stitches, the use of arthroscopy, open or combined surgery, the associated procedures, if performed, and the presence or absence of reaming, and its type.

The rehabilitation protocol was also studied with a possible limitation of flexion, the wearing of a splint and its type, and the immediate or delayed resumption of weight-bearing. The delay could be 4 to 6 weeks depending on the center's protocol.

The primary endpoint at 5 years or more was suture survival and time before its revision. Failure was defined as the need for a meniscectomy.

Functional scores at follow-up were assessed by patient questionnaires, including the KOOS [18] and Tegner [19] scores while identifying risk factors for failure, which defined the secondary endpoint.

The entire cohort was analyzed and then separated into bucket-handle tears and the rest of the cohort.

2.1. Data collection and statistics

Data collection and statistical analysis was carried out by each participating center using the EasyMedStat online application (version 3.20.4; www.easymedstat.com).

Continuous variables were expressed by their means (± standard deviation) [interquartile range 25%–75%] and discontinuous variables by the number of occurrences and percentages.

The normality of distribution of the continuous variables was assessed by a Shapiro-Wilk test and the heteroscedasticity of the values by the Breush-Pagan and Levene tests.

Continuous variables were compared using an unpaired Student's *t*-test, Welsh's *t*-test, or a Mann-Whitney test depending on their distribution. Discontinuous variables were compared according to a Chi-square test or a Fisher exact test.

Survival probabilities were estimated using a Kaplan-Meier method and their result was expressed as a percentage with a 95% confidence interval. The comparison of survivals between two groups was carried out by the Cloglog method.

A multivariate risk factor analysis was performed using logistic regression. The multicollinearity of the values was tested by a Belsley-Kuh-Welsch test. The result was expressed in the form of an Odds-Ratio (OR) with a 95% confidence interval.

An alpha risk was chosen at 5%, and the results were considered significant for a *p*-value less than 0.05.

3. Results

3.1. Description of the overall cohort

A total of 367 knees (99 women, 268 men) were included in the retrospective series, the demographics of this cohort and the characteristics of the meniscal lesions are summarized in Table 1. The population was mainly composed of young (28.3 years on average) men (73%), with a MM tear from sports trauma (43%). The tear was typically a bucket-handle tear (122 knees, 33%), horizontal (103 knees, 28%) or vertical (99 knees, 27%) and sutured mainly by an all-inside technique (246 sutures, 67%), with surgical reaming in all cases.

Table 1
Demographic characteristics of the population.

	Cohort ($n = 367$)	Bucket-handle ($n = 122$)	Other ($n = 245$)	p
Sex (female)	99 (27%)	21 (17%)	79 (32%)	0.003
Age (years)	28.3 ± 10 [20–35]	27 ± 9	29 ± 11	0.07
BMI (293)	23.4 ± 3 [21–25]	23 ± 3	23 ± 4	0.348
Smoking	81/291 (28%)	33/87 (38%)	44/178 (25%)	0.037
Injury mechanism				
Trauma	227/325 (70%)	100/117 (85%)	143/233 (61%)	< 0.001
from sport	141/227 (62%)	76/112 (68%)	96/163 (59%)	0.167
from pivoting	119/141 (84%)	69/76 (91%)	78/101 (77%)	0.029
Preoperative Tegner score	5.6 ± 2 [4–7]	6 ± 2	5 ± 2	0.002
Preoperative KOOS score				
Everyday life	89 ± 20 [91–98]	80 ± 23	94 ± 10	0.002
Quality of life	55 ± 23 [44–73]	42 ± 25	64 ± 18	< 0.001
Pain	76 ± 16 [70–84]	66 ± 18	83 ± 10	< 0.001
Sport	59 ± 28 [42–79]	43 ± 31	70 ± 20	< 0.001
Symptoms	78 ± 21 [68–83]	65 ± 23	87 ± 13	< 0.001
Preoperative HKA (95)	179.2 ± 3 [177–180]	179 ± 3	179 ± 3	0.496
Morphotype: (95)				0.413
Aligned	52%	48%	57%	
Varus	40%	46%	35%	
Valgus	8%	6%	9%	
Radiography: (100)				
Tibial slope	5.8 ± 1.9 [5–7]	6 ± 2	6 ± 2	0.078
α angle	96.5 ± 3 [95–97]	96 ± 4	97 ± 2	0.765
β angle	87.1 ± 2 [86–88]	87 ± 3	87 ± 2	0.969
MRI: (147)				
Tibial slope	5.8 ± 2 [4–7]	5 ± 2	6 ± 2	0.022
α angle	95.9 ± 4 [94–98]	95 ± 4	96 ± 4	0.384
β angle	87.3 ± 3 [86–88]	87 ± 3	87 ± 3	0.091
Zone of the lesion: (367)				0.022
1	57%	44%	63%	
2	37%	48%	30%	
3	6%	8%	7%	
Meniscal lesion type: (367)				
Bucket-handle	34%			
Horizontal	28%			
Vertical	27%			
Complex	6%			
Ramp	3%			
Root	2%			
ICRS lesion: (323)				0.225
0	78%	87%	75%	
1	10%	6%	10%	
2	10%	6%	12%	
3	2%	1%	3%	
Type of suture: (367)				< 0.001
All inside	67%	67%	68%	
Mixed	17%	32%	8%	
Open surgery	11%	0%	17%	
Hook	4%	0%	5%	
Other	1%	1%	2%	
Number of points (367)	3.2 ± 1.5 [2–4]	4 ± 1	3 ± 2	< 0.001
Reaming (367)	360 (98%)	97%	99%	0.097
Type				< 0.001
Curette		0%	17%	
Reamer		30%	45%	
Shaver		70%	38%	
Postoperative (322)				
Weight-bearing	312 (85%)	86%	83%	0.568
Flexion limited to 90°	356 (97%)	97%	97%	> 0.999
Splint	272 (74%)	79%	65%	0.013
of the joint	95/225 (42%)	26%	52%	< 0.001
only when walking	155/225 (69%)	64%	71%	0.152

Data described according to mean ± standard deviation [Q1–Q3] or number (percentage %) In the event of missing data, the number of patients is represented in parentheses for continuous values or given as a fraction for discontinuous values. BMI: body mass index (kg/m^2); HKA: hip knee ankle angle.

The clinical results are shown in Table 2.

Figs. 1 and 2 represent the survival curves of the entire cohort, and the comparison between bucket-handle tears and other types of lesions respectively.

Tables 3, 4 and 5 present the risk factors associated with suture failure in multivariate analysis for each cohort (overall cohort, bucket-handle tears, other lesions).

3.1.1. Overall cohort analysis

The survival of the overall cohort was 67% at 5 years. For the overall cohort, age seems to be a protective factor with a decrease in the risk of suture failure for each increase in years during the surgical procedure [OR = 0.966 (0.94; 0.99), $p = 0.0153$]. Bucket-handle tear [OR = 1.71 (1.02; 2.9), $p = 0.0437$], immediate weight-bearing [OR = 3.6 (1.62; 7.98), $p = 0.016$] and wearing a splint

Table 2
Clinical results.

	Cohort ($n = 367$)	Bucket-handle ($n = 122$)	Others ($n = 245$)	p
Follow-up (months)	82 ± 44 [62–111]	98 ± 42	74 ± 42	0.003
Failures	112/337 (33%)	42%	26%	0.003
Time until failure	26 ± 27 [8.5–35]	26 ± 25	28 ± 30	0.704
Tegner at follow-up	5.4 ± 2 [4–7]	6 ± 2	5 ± 2	0.002
Tegner progression	−0.2 ± 1 [−1–0]	−0.1 ± 1	−0.2 ± 1	0.714
KOOS at follow-up: (95)				
Daily life	95 ± 9 [96–100]	96 ± 6	95 ± 10	0.288
Quality of life	72 ± 30 [66–94]	72 ± 30	72 ± 31	0.884
Pain	91 ± 16 [89–97]	91 ± 17	90 ± 16	0.84
Sport	76 ± 31 [65–100]	73 ± 31	77 ± 32	0.133
Symptoms	86 ± 24 [86–100]	88 ± 23	86 ± 25	0.885
KOOS progression: (66)				
Daily life	12 ± 18 [0–12]	23 ± 22	6 ± 11	0.003
Quality of life	30 ± 24 [13–44]	44 ± 25	21 ± 20	< 0.001
Pain	21 ± 17 [11–28]	33 ± 19	14 ± 10	< 0.001
Sport	30 ± 25 [15–50]	44 ± 27	21 ± 20	< 0.001
Symptoms	18 ± 21 [3–27]	35 ± 23	8 ± 13	< 0.001
Probability of survival:				
At 1 year	88% [84–91]	82% [74–88]	91% [86–94]	0.0196
At 2 years	79% [74–83]	75% [66–82]	84% [78–89]	0.0456
At 5 years	70% [65–75]	61% [52–70]	77% [71–83]	0.0044
At 10 years	65% [60–70]	56% [46–65]	73% [66–79]	0.0041

Data described according to mean ± standard deviation [Q1–Q3] or number (percentage %). In the event of missing data, the number of patients is represented in parentheses for continuous values or given as a fraction for discontinuous values. For survival analyses: % [95% confidence interval].

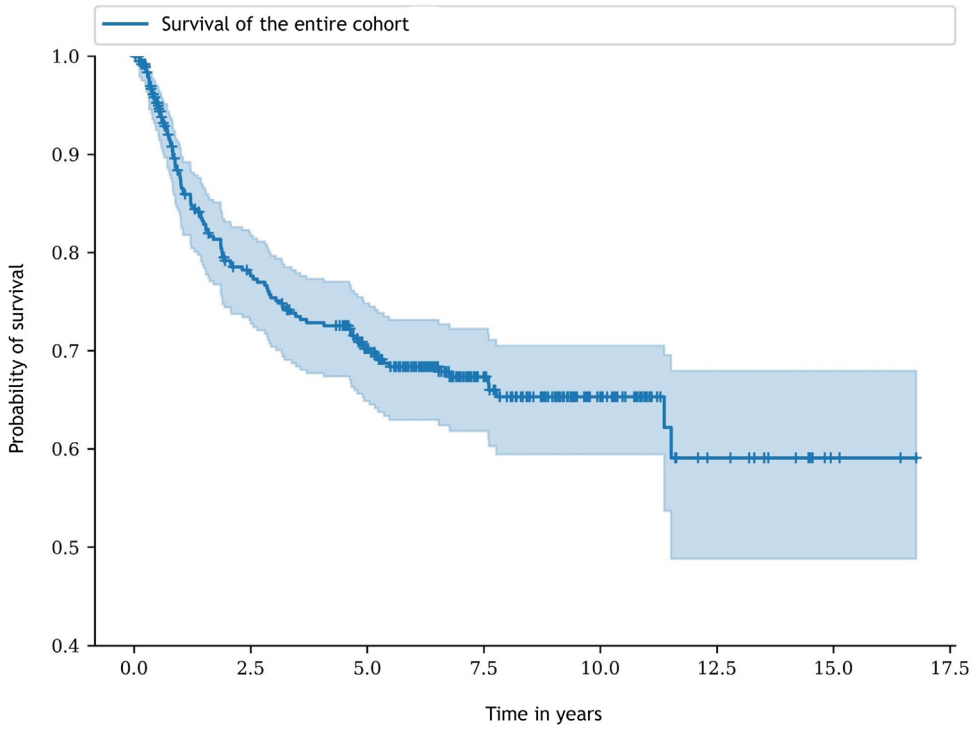

Fig. 1. Survival curve of the entire cohort.

Table 3
Results of the multivariate analysis of risk factors (entire cohort).

$n = 318$	Odds-ratio	p
Gender (reference = M)	1.39 [0.76; 2.5]	0.282
Age (risk per additional year)	0.966 [0.94; 0.99]	0.0153
BMI (risk per additional kg/m^2)	1 [0.91; 1.1]	0.935
Smoking	1.49 [0.83; 2.7]	0.185
Bucket-handle tear	1.71 [1.02; 2.9]	0.0437
Chondral lesions (< 2 or =2)	0.78 [0.31; 2.01]	0.609
Weight-bearing	3.6 [1.62; 7.98]	0.0016
Splint	2.83 [1.54; 5.2]	< 0.001

Data described according to the odds-ratio [95% confidence interval].

Table 4
Results of the multivariate analysis of risk factors (bucket-handle group).

$n = 79$	Odds-ratio	p
Gender (reference = M)	4.85 [1.07; 21.91]	0.04
Age (risk per additional year)	0.943 [0.881; 1.01]	0.089
BMI (risk per additional kg/m^2)	1.05 [0.866; 1.28]	0.6
Smoking	5.76 [1.81; 18.35]	0.003
Weight-bearing	8.98 [1.46; 55.37]	0.0181
Splint	2.77 [0.689; 11.13]	0.151

Data described according to the odds-ratio [95% confidence interval].

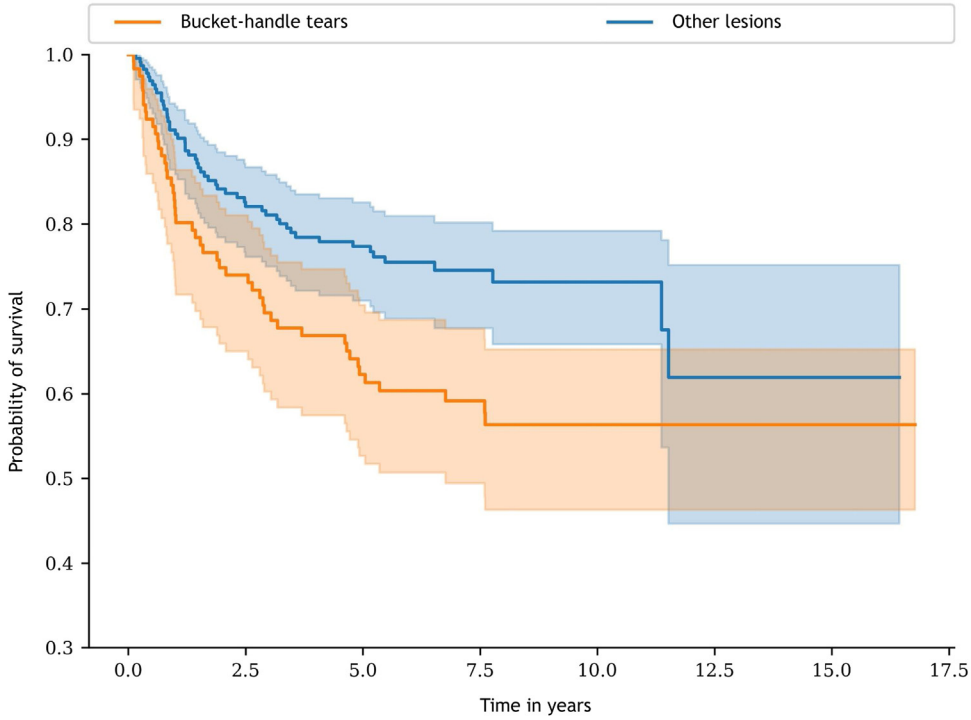

Fig. 2. Survival curve comparing bucket-handle tears to other lesions.

Table 5
Results of the multivariate analysis of risk factors (other lesions group).

n = 209	Odds-ratio	*p*
Gender (reference = M)	1.26 [0.607; 2.62]	0.534
Age (risk per additional year)	0.975 [0.943; 1.01]	0.139
BMI (risk per additional kg/m^2)	0.977 [0.861; 1.1]	0.708
Smoking	0.685 [0.286; 1.64]	0.396
Weight-bearing	4.84 [1.55; 15.08]	0.0065
Splint	3.9 [1.76; 8.66]	< 0.001

Data described according to the odds-ratio [95% confidence interval].

postoperatively [OR = 2.83 (1.54; 5.2), $p < 0.001$] are the main risk factors found.

3.1.2. Analysis by type of lesion

3.1.2.1. Bucket-handle tears. Bucket-handle tears benefited from longer follow-up and showed better progression of all KOOS subscores. On the other hand, their failure rate was higher, at 42%. Smoking was a failure risk factor for bucket-handle tears [OR = 5.76 (1.81; 18.35), $p = 0.003$], as was female sex [OR 4.85 (1.07; 21.91), $p = 0.04$] and weight-bearing [OR = 8.98 (1.46; 55.37), $p = 0.0181$]. On the other hand, there was no increased risk, nor protective factor, for age or splint use.

3.1.2.2. Other types of lesions. Survival at 5 years of follow-up was higher for these lesions, with survival reaching 77% [71–83].

Immediate weight bearing [OR = 4.84 (1.55; 15.08), $p = 0.0065$] and splint use [OR = 3.9 (1.76; 8.66), $p < 0.001$] were the only risk factors for failure identified.

4. Discussion

MM sutures in stable knees have satisfactory survival at 5 years of follow-up, but with a difference depending on the type of lesion and a higher failure rate for bucket-handle tears. The clinical results are favorable with an improvement in the KOOS score [18], specifically for the bucket-handle tears in our series.

Amongst the literature, good postoperative clinical results exist for meniscal sutures. At the SFA symposium in 2015, Lutz et al. [6] found KOOS scores above 90, at 10 years for meniscal sutures (except for sport with a score of 54). These results are higher than ours (respectively 95, 72, 91, 76, 86). Their series had fewer sutures and their number was more variable, including medial and lateral meniscal sutures.

The survival of the overall cohort in our series was 67% at 5 years.

In a retrospective study of 918 meniscal sutures in 2020, including medial and lateral sutures as well as unstable knees, Ronnblad et al. [9] found a suture failure rate lower than ours (22% vs. 33%).

Similar failure rates were found in a meta-analysis by Nepple et al. [20] in 2012 with a failure rate between 20.2 and 24.3%. This analysis included medial and lateral menisci but also unstable knees.

This survival rate is variable according to the type of lesion in the literature.

We found a failure rate of 18% at one year for bucket-handle tears compared to 29.3% of failure at 13 months for Ardizzone et al. [11], in their 2020 study of 396 bucket-handle tears.

The study by Salle De Chou et al. [7] found low rates of revision surgery for sutures of horizontal tears, also of the medial and lateral menisci, with one failure out of 18 for one of their cohorts at 2 years and no failures out of nine for another cohort at 10 years. The good success rate of these lesions could explain the difference between our two cohorts.

In a 2022 meta-analysis of more than 800 meniscal lesions (including medial and lateral tears as well as lesions associated with ACL tear), Costa et al. [8] found a risk of failure for bucket-handle tears with an OR of 1.5 (1.15-2.05), as well as a failure rate of 14.8% for bucket-handle tears and 9.9% for other types of lesions. Our study identified a higher failure rate (42% vs. 26%) but with a longer follow-up. On the other hand, the OR of bucket-handle tears identified in our study was 1.71 [1.02; 2.9], which corresponds with the results of the meta-analysis. It should be noted that medial meniscus sutures were much more at risk of failure than lateral meniscus

sutures [8,9], which may also explain our higher failure rate than those found in the literature.

Another major risk factor found in the literature is the integrity of the collateral ligaments [8,10]. Ronnblad et al. [9] found a hazard ratio for medial sutures of 3.7; 95% CI, 2.3-6.0; $p < 0.001$ and for sutures during ACL reconstruction of 0.5; 95% CI, 0.3-0.9; $p = 0.009$. Turcotte [10] obtained a failure rate of 9.7% in the medium term for meniscal repairs concomitant with ACL reconstruction, compared to 36% in the case of intact collateral ligaments. This could explain the significant difference between our rates of overall survival and the findings of others in the literature, since our cohort combines predictive factors of failure (MM, stable knee, bucket-handle tear).

In our study isolating sutures of the MM in stable knees, the risk factors found for the entire cohort were bucket-handle tears, immediate weight-bearing, wearing a splint and young age, the last two being statistically related to bucket-handle tears. The only risk factor for failure found in the "bucket-handle tears" subgroup and the "other lesions" subgroup was immediate weight-bearing with a high OR (8.98 and 4.84).

Although bucket-handle tears are known to be at high risk of failure [10], repair is still recommended, in order to reduce the risk of osteoarthritis and allow recovery towards better long-term knee function [21].

Actually, rehabilitation protocols after meniscal repair surgery are extremely varied among the orthopedic community. A consensus concerning the optimal postoperative protocol is lacking with regard to both the immediate postoperative phase [22], and the return to sport stage [23].

Wearing a splint was not identified as a risk factor for failure in the bucket-handle group but it was identified in the other subgroup, which can be explained by a high rate of splint wearing in the bucket-handle group. This makes it less discriminating and, conversely, only being worn in cases of difficult lesions in the "other lesions" group.

Smoking was only identified as a risk factor in the bucket-handle group. Furthermore, smoking does not appear to be a prognostic factor in the literature [24]. Additional studies are needed to investigate the risk factors concerning postoperative rehabilitation protocols after meniscal repair, in greater detail. Particularly, the resumption of immediate weight-bearing, as well as smoking.

This study has some limitations, predominantly, its retrospective nature leading to loss of follow-up in this population of young and active patients. The multicentric nature of the study also introduced a confusion bias with certain center effects, since certain teams sutured more of certain types of lesions, and used different methods, while certain centers had their own postoperative protocols conferring further variation from others.

Our study, carried out as part of a SFA symposium, had the advantage of including 10 reference centers in knee arthroscopy with a large number of staff representative of French practices in terms of MM suture in stable knees. This study was the first to isolate these lesions at more than 5 years of follow-up, allowing sufficient follow-up to study all suture failures.

5. Conclusion

MM sutures in stable knees improve knee function but present a risk of failure that varies according to the type of lesion treated, with a higher risk of failure for bucket-handle tears. Caution needs to apply when considering the resumption of weight-bearing and the influence of smoking. This knowledge makes it possible to provide better information to the patient when proposing this surgical intervention.

Large cohorts of patients, categorized by subtypes of lesion, remain difficult to establish but should be more readily available in the future due to the development of registers of meniscal lesions.

Disclosure of interest

SP is a consultant for Corin. OC and BF are consultants for Arthrex. VP is a consultant for Smith and Nephew. The other authors declare that they have no competing interest.

Funding

The authors would like to thank the SFA for the funding of the statistical component of this study.

Participation and contribution of the authors in this study

All the co-authors participated in the data collection for their respective centers: Simon Pelletier and Nicolas Graveleau for the Bordeaux Mérignac centre, Azeddine Djebara for the Versailles hospital center, Benjamin Freychet for the Santy orthopedic center in Lyon, Olivier Carnessechi for the Ortheo center in Saint Etienne, Marie Laure Louis for the Institute of orthopedic and sports surgery center in Marseille, Kevin Benad for the Nord Genou center in Lille, Cesar Praz and Gaelle Maroteau for Caen University Hospital, Sammy Badr for the Roger Salengro Hospital Center in Lille, Henri Favreau for Strasbourg University Hospital, Vincent Pineau for the Médipole Garonne Clinic in Toulouse, Teddy Trouillez and Sophie Putman for the Lille University Hospital.

Simon Pelletier participated in the statistical analyzes and the writing of the article. Azzedine Djebarra, Benjamin Freychet and Sophie Putman also participated in writing the article.

Use of AI

No artificial intelligence was used for writing the submitted work.

Acknowledgements

The authors would like to thank Easymedstat for their help in relation to this study.

References

[1] Hede A, Larsen E, Sandberg H. Partial versus total meniscectomy. A prospective, randomised study with long-term follow-up. J Bone Joint Surg Br 1992;74:118–21.
[2] Parker BR, Hurwitz S, Spang J, Creighton R, Kamath G. Surgical trends in the treatment of meniscal tears: analysis of data from the American Board of Orthopaedic Surgery Certification Examination database. Am J Sports Med 2016;44:1717–23.
[3] Kurzweil PR, Cannon WD, DeHaven KE. Meniscus repair and replacement. Sports Med Arthrosc Rev 2018;26:160.
[4] Woodmass JM, LaPrade RF, Sgaglione NA, Nakamura N, Krych AJ. Meniscal repair: reconsidering indications, techniques, and biologic augmentation. JBJS 2017;99:1222.
[5] Beaufils P, Pujol N. Meniscal repair: technique. Orthop Traumatol Surg Res 2018;104:S137–45.
[6] Lutz C, Dalmay F, Ehkirch F-P, Cucurulo T, Laporte C, Le Henaff G, et al. Meniscectomy versus meniscal repair: 10 years' radiological and clinical results in vertical lesions in stable knee. Orthop Traumatol Surg Res 2015;101:S327–31.
[7] Sallé de Chou E, Pujol N, Rochcongar G, Cucurulo T, Potel JF, Dalmay F, et al. Analysis of short and long-term results of horizontal meniscal tears in young adults. Orthop Traumatol Surg Res 2015;101:S317–22.
[8] Costa GG, Grassi A, Zocco G, Graceffa A, Lauria M, Fanzone G, et al. What is the failure rate after arthroscopic repair of bucket-handle meniscal tears? A systematic review and meta-analysis. Am J Sports Med 2022;50:1742–52.
[9] Ronnblad E, Barenius B, Engstrom B, Eriksson K. Predictive factors for failure of meniscal repair: a retrospective dual-center analysis of 918 consecutive cases. Orthop J Sports Med 2020;8, http://dx.doi.org/10.1177/2325967120905529, 2325967120905529.

[10] Turcotte JJ, Maley AD, Levermore SB, Petre BM, Redziniak DE. Risk factors for all-inside meniscal repair failure in isolation and in conjunction with anterior cruciate ligament reconstruction. Knee 2021;28:9–16.
[11] Ardizzone CA, Houck DA, McCartney DW, Vidal AF, Frank RM. All-inside repair of bucket-handle meniscal tears: clinical outcomes and prognostic factors. Am J Sports Med 2020;48:3386–93.
[12] Meneghini RM, Mont MA, Backstein DB, Bourne RB, Dennis DA, Scuderi GR. Development of a modern knee society radiographic evaluation system and methodology for total knee arthroplasty. J Arthroplasty 2015;30 :2311–4.
[13] Zampogna B, Vasta S, Amendola A, Uribe-Echevarria Marbach B, Gao Y, Papalia R, et al. Assessing lower limb alignment: comparison of standard knee X-ray vs. long leg view. Iowa Orthop J 2015;35:49–54.
[14] Kostogiannis I, Swärd P, Neuman P, Fridén T, Roos H. The influence of posterior-inferior tibial slope in ACL injury. Knee Surg Sports Traumatol Arthrosc 2011;19:592–7.
[15] van Raaij TM, Brouwer RW, Reijman M, Bierma-Zeinstra SMA, Verhaar JAN. Conventional knee films hamper accurate knee alignment determination in patients with varus osteoarthritis of the knee. Knee 2009;16:109–11.
[16] Hudek R, Schmutz S, Regenfelder F, Fuchs B, Koch PP. Novel measurement technique of the tibial slope on conventional MRI. Clin Orthop 2009;467:2066–72.
[17] Sauer S, English R, Clatworthy M. The ratio of tibial slope and meniscal bone angle for the prediction of ACL reconstruction failure risk. Surg J N Y N 2018;4:e152–9.
[18] Ornetti P, Parratte S, Gossec L, Tavernier C, Argenson J-N, Roos EM, et al. Cross-cultural adaptation and validation of the French version of the Knee injury and Osteoarthritis Outcome Score (KOOS) in knee osteoarthritis patients. Osteoarthritis Cartilage 2008;16:423–8.
[19] Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. Clin Orthop 1985;198:43–9.
[20] Nepple JJ, Dunn WR, Wright RW. Meniscal repair outcomes at greater than five years: a systematic literature review and meta-analysis. J Bone Joint Surg Am 2012;94:2222–7.
[21] Kalifis G, Raoulis V, Panteliadou F, Liantsis A, D'Ambrosi R, Hantes M. Long-term follow-up of bucket-handle meniscal repairs: chondroprotective effect outweighs high failure risk. Knee Surg Sports Traumatol Arthrosc 2022;30:2209–14.
[22] Spang III RC, Nasr MC, Mohamadi A, DeAngelis JP, Nazarian A, Ramappa AJ. Rehabilitation following meniscal repair: a systematic review. BMJ Open Sport Exerc Med 2018;4:e000212.
[23] Schwach M, Dergham R, Klasan A, Putnis S, Farizon F, Philippot R, et al. Return-to-sport criteria after isolated meniscus suture: scoping review of the literature. Orthop Traumatol Surg Res 2023:103604, http://dx.doi.org/10.1016/j.otsr.2023.103604.
[24] Laurendon L, Neri T, Farizon F, Philippot R. Prognostic factors for all-inside meniscal repair. A 87-case series. Orthop Traumatol Surg Res 2017;103:1017–20.