



## Research Article

# Do Meniscal Procedure Volumes Reflect Meniscal Tear Practice Guidelines? A Narrative Review Comparing Guidelines and Procedural Volume Data from the United States, Europe and Japan

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### ABSTRACT

**Purpose:** This narrative review aimed to summarise international guidelines on the surgical management of meniscus tears and consider the extent to which they are reflected in clinical practice by reporting the respective trends in meniscus repair and resection procedure volumes.

**Methods:** Two targeted reviews of the literature were conducted using a snowballing approach; the first sought to capture clinical guidelines covering meniscal repair, whilst the second aimed to identify data on meniscal repair procedure volumes.

**Results:** Meniscal repair guidelines (n=7) and volume trends (n=5) were identified spanning Canada, France, Japan, the Netherlands, the United States and the United Kingdom, as well as Europe as a whole. Guidelines from different countries varied in the amount of detail included about different tear types, and the age ranges for which meniscal repairs- were considered most appropriate. Guidelines across different countries generally recommended the use of meniscal repairs where possible, on the basis that repairs are associated with better long-term outcomes compared with meniscectomies.

**Conclusion:** Procedure volume trends showed that, in line with international guidelines, the rates of meniscal repair increased in the period considered. However, meniscectomy remained the most widely used approach to managing meniscal injuries over the period reviewed. This may have important consequences for patient outcomes and resource use in the long-term, as meniscectomy has been shown to be related to increased incidence of osteo-arthritis and total joint replacement. The inconsistency between guidelines and practice warrants further research into whether the guidelines reflect current medical opinion as well as how to improve compliance with best practice recommendations.

**Keywords:** Meniscus; Meniscal repair; Meniscal resection; Meniscus tear; Meniscectomy, Guidelines

## Introduction

The meniscus serves a fundamental role in knee kinematics, important for load transmission, shock absorption and knee stability [1]. Trauma to the meniscus is common. In the United States (US) [2] the incidence of meniscus injury is 0.6–0.7 tears per 1000 person years; this varies across populations [2]. Whilst meniscus tears can occur across all ages, sexes and activity levels, the specific tear types and treatments vary [2]. The incidence of meniscal injuries typically follows a two-peak distribution, with a significant proportion of traumatic tears occurring in younger, more active groups (female: 11–20 years; male: 21–30 years), or relatively older groups, potentially due to degenerative joint disease (female: 61–70 years; male: 31–40 years) [3]. In males, the number of meniscal tears is generally higher than in females, and the degenerative pattern occurs earlier but falls precipitously after the age of 40; comparatively, females show two widely disparate peak incidences, with the degenerative pattern peaking later, but remaining stable thereafter, to resemble the incidence seen in males after the age of 70 [3]. The characteristics of the two-peak distribution vary between studies, particularly across different geographies [4,3]. Moreover, meniscal tear is associated with Anterior Cruciate Ligament (ACL) injury and occurs with a greater incidence in patients who do not undergo arthroscopy within eight weeks of injury [5].

Conservative therapy (e.g. physiotherapy, rest, symptom monitoring) is usually the first line of treatment following a suspected meniscal tear [6]. Nonetheless, meniscal injuries commonly require surgery, particularly when ACL reconstruction is needed or when symptoms are more severe (e.g. locked knee) [7,8]. Approximately 850,000 meniscus surgeries are conducted annually in the US, comprising 10–20% of orthopaedic surgeries each year [2]. Surgical options for meniscus tears can be broadly grouped into meniscectomy and meniscal repair [8]. Meniscectomy involves removing the damaged tissue and contouring the remaining healthy meniscal tissue to provide a stable peripheral rim, resulting in faster recovery and a reduced risk of re-tear [9]. Despite these short-term benefits, removal of the meniscal tissue results in bone-on-bone friction and may increase the long-term risk of Osteoarthritis (OA) and requirement for joint replacement [10,11].

Meniscal repair involves leaving some or all of the meniscal tissue *in situ* and using stitches to close the tear [8]. Whilst retention of the viable tissue is beneficial as it may reduce the risk or delay the onset of OA [2], meniscal repair requires a longer recovery period compared with meniscectomy, ranging from 4–12 months post-operation compared with 7–9 weeks, respectively [13, 14]. A

large database study indicated that the rate of early complications are significantly higher following repair (1.2%) compared with meniscectomy (0.8%) [15]. However, the same study found that the rate of re-operation was significantly lower following repair (2.1%) than meniscectomy (5.3%) [15]. The features of meniscectomy and meniscus repair create a dichotomy for healthcare providers and patients. Meniscectomy offers a faster recovery compared with repair, which is particularly beneficial to sports professionals, for example, looking to return to activity quickly [9, 8, 16]. However, meniscectomy is associated with a greater long-term risk of OA, functional limitation and mobility impairment [9,8]. Moreover, with health systems facing increasing financial pressures, costs may influence surgical decision-making. However, there is no consensus on the most cost-effective procedure. Whilst repair is associated with higher short-term costs, due to greater surgical complexity and recovery time, the reduced risk of OA contributes to its long-term cost-effectiveness [17, 2]. The aim of this review is to assess guidelines on the surgical management of meniscus tears, and to consider the extent to which the guidelines are reflected in practice by reporting the trends in meniscus repair and meniscectomy procedure volumes.

## Methods

Two targeted literature reviews were conducted between May–August 2021; the first sought to capture the clinical guidelines covering meniscal repair, and the second to identify procedure volume data. For both, results were limited to data available in the English language. A snowballing approach was adopted to identify international guidelines for meniscal repair covering the US/Canada, Europe and Japan. This approach began with known guidelines including those from the European Society for Sports Traumatology, Knee Surgery And Arthroscopy (ESSKA) and the American Academy of Orthopaedic Surgeons (AAOS), then identified additional guidelines based on searches of the reference lists and relevant surgical societies in each region. Further searches of medical literature (PubMed) and internet searches were also conducted, using the search terms ‘meniscal repair’, ‘meniscectomy’, ‘meniscal resection’ and ‘meniscal surgery’. Guidelines published from the year 2000 onwards were included. A data extraction template was developed to extract consistent information from each guideline, including patient selection, criteria for meniscal repair, details of surgical approaches and concomitant treatments, where stated. Data on meniscal repair procedure volumes were identified through targeted medical literature and internet searches. Search terms relating to meniscal surgery, meniscal resection and meniscal repair were used, including Medical Subject Headings (MeSH) terms relating to surgical procedure trends and time series. Studies reporting longitudinal procedure volumes, including meniscal repair and meniscectomy (with or without ACL repair) were considered for inclusion to ensure that trends in surgery could be identified, rather

than point estimates at a given time. Studies published prior to 2010 were excluded on the basis that these were unlikely to reflect current practice and recent recommendations from the guidelines; studies published after 2010 with time series starting prior to 2010 were considered for inclusion to maximise the time series data included. Studies were identified for inclusion for based on the countries identified in the guideline review in an attempt to match the procedure volume data by country; studies reporting procedure volume data for countries which did not have identified meniscal repair guidelines were excluded. Data on procedure volumes and case-mix (i.e. the proportion of meniscal repair versus meniscectomy) were extracted using a data extraction template.

## Results

### Clinical guidelines on meniscal repair

Seven guidelines published between 2008–2020 were included in the analysis, spanning Canada [18], France [19], Japan [20], the Netherlands [21], United Kingdom (UK) [22], US [23] and Europe as a whole [7] (Table 1,2). Guidelines on meniscal tears included recommendations for both conservative management and surgical interventions; four guidelines were specific to meniscal tears [3,18,21,22], whilst three (in Europe [7], France [19], Japan [20]) included guidance on the management of ACL injuries, with or without meniscal injury. Guidelines generally emphasised the need to preserve the meniscus and highlighted the long-term benefits of repair compared with meniscectomy, such as greater patient satisfaction and activity post-repair (Europe [19]), and reduced risk of progressive OA (Europe [7], France [19], Japan [20], US [3]). Three guidelines recommended meniscal repair as the first line of surgery where feasible (Europe [7], France [19], the Netherlands [21]); for non-repairable tears, partial meniscectomy

was recommended on the condition that the injury is symptomatic (France [19], UK [22]). Guidelines predominantly focused on patient age and tear type as two key indications determining preferences for meniscal repair versus meniscectomy. Meniscal repair was specifically recommended for its benefit in younger (<40 years) but not older (>40 years) patients in the US [23], or those with degenerative tears or OA; in these patients, meniscectomy was recommended (Europe [7], France [19], the Netherlands [21], US [23]). An important consideration guiding the preference for repair in younger patients was the expected risk of arthritic progression following meniscectomy (US [23]). Undergoing meniscectomy earlier in life may increase the duration patients suffer arthritic symptoms following the procedure, whereas older patients are less likely to be impacted by this effect due to shorter life-expectancy and greater likelihood of pre-existing OA symptoms (US [23]). Repair was recommended over meniscectomy for acute or recent tears (Europe [7], France [19], UK[22], US [20]), traumatic tears (Europe [7], France [19]), well-vascularised tears (France [19], US [23]), peripheral tears (France [19], the Netherlands [21]), lateral meniscus tears (Canada [18], France [19], the Netherlands [21]), and vertical tears (US [23]). However, guidelines noted little benefit of repair in avascular tears (US [23]), non-traumatic tears (France [7]), radial tears (Europe [7], US [23]) and horizontal tears (US [23]); for these tears, meniscectomy was recommended. The level of detail describing the differential indications for repair versus meniscectomy varied across the guidelines. For instance, the Japanese guidelines were restricted to meniscal repair with concomitant ACL injury (Japan [20]), and the Canadian guidelines focused on knee arthroscopy procedures for the meniscus, with limited detail on repair technique (Canada [18]). (Table 1) (Table 2).

Guideline Name	Professional Body, Country/Region	Year of Publication	Indications Covered
Management of traumatic meniscus tears: the 2019 ESSKA meniscus consensus [19]	ESSKA, Europe	2020	o Meniscal repair
			o Left <i>in situ</i>
			o Partial meniscectomy
			o Concomitant ACL reconstruction
Meniscal repair [20]	AAOS, US	2013	o Meniscal repair
Treatment of meniscal lesions and isolated lesions of the anterior cruciate ligament of the knee in adults – Clinical practice guideline [11]	HAS, France	2008	o No surgery
			o Meniscal repair
			o Meniscectomy
			o ACL reconstruction with or without meniscal lesion
Treatment guidance: arthroscopic meniscal surgery [1]	BASK, UK	2018	o Non-operative
			o Meniscal repair
			o Meniscectomy
JOA clinical practice guidelines on the management of anterior cruciate ligament injury [12]	JOA, Japan	2020	o ACL injury incl. concomitant meniscal repair
Dutch guideline on knee arthroscopy part 1, the meniscus: a multidisciplinary review by the Dutch Orthopaedic Association [32]	NOV, the Netherlands	2020	o Knee Arthroscopy procedures for meniscus
Position statement of the AAC concerning arthroscopy of the knee joint [33]	AAC, Canada	2018	o Degenerative Meniscal Tear

**Table 1:** Clinical guidelines on meniscal repair: indications covered.

**Abbreviations.** AAC: Arthroscopy Association of Canada; AAOS: American Academy of Orthopaedic Surgeons; ACL: anterior cruciate ligament; BASK: British Association for Surgery of the Knee; ESSKA: European Society for Sports Traumatology, Knee Surgery and Arthroscopy; HAS: Haute Autorité de Santé; JOA: Japanese Orthopaedic Association; NOV: Nederlandse Orthopaedische Vereniging; UK: United Kingdom; US: United States.

Guideline	Meniscal repair		Meniscectomy		Notes
	Criteria	Contraindications/ considerations	Criteria	Contraindications/ considerations	
ESSKA, Europe [19]	o Patient age: younger patients	o Long recovery time	o Tear type: radial tears Zone 3	o Risk of OA	o Zone 3 tears should not be considered as an absolute contraindication for meniscus repair
	o BMI: up to 35	o Age does not appear to affect the failure rate of repairs of traumatic meniscus tears (available studies included patients with ages 9 to 58 years) however degeneration of the meniscus tissue in older patients is highlighted as a consideration		o Higher patient satisfaction and activity after repair compared to meniscectomy	o Length of the meniscus tear should not be a contraindication for repair or partial meniscectomy
	o Timing of Injury: acute tears, chronic tears only when indicated	o BMI: >35		o Inferior clinical and radiological long-term outcome after partial meniscectomy compared to meniscus repair	
	o Tear type: unstable tears (such as bucket handle and double longitudinal tears), isolated meniscus tears, radial tears: Zones 1 and 2, posterolateral meniscus root tears	o Tear type: complex tears, flap tears or nonreducible bucket handle tears, radial tears: Zone 3			
	o Tear location: Cooper zones 1 and 2, anterior horn, posterior horn, pars intermedia, medial meniscus tears	o Isolated meniscus repairs in unstable knees, such as an ACL-deficient knee			
	o Tear length: any length longitudinal traumatic tear	o Small tears ( $\leq 10$ mm) of the lateral meniscus			

AAOS, US [20]	o Patient age: <40 years	o Patient age: older patients with degenerative tears	o Patient age: older patients with degenerative tears	o Early development of knee OA	o Even a small decrease in meniscus volume may alter knee mechanics, resulting in increased peak pressures and mean contact pressure
	o Timing of injury: acute tears (i.e. <6 weeks)	o Tear type: horizontal, radial, complex	o Tear type: radial, horizontal	o Repair should be favoured in younger patients because arthritic progression takes years to develop following meniscectomy; undergoing the procedure early in life increases the likelihood that patients will experience symptoms and suffer a longer duration of associated morbidities, whereas this is less of a concern in older patients -	o Controversy persists regarding whether repair is associated with significantly better success in younger patients, or whether there is no difference in the healing response following repair depending on age
	o Tear type: vertical tears, substantial radial tears that extend the entire width of the meniscus	o Tear location: avascular zone tears			
	o Tear location: red-red zone tears	o Postoperative limitations of meniscal repair are markedly greater than those of partial meniscectomy			
	o Tear length: >1 cm and <4 cm in length				
	o No mechanical axis malalignment				
	o Concurrent ACL				

HAS, France [11]	o Patient age: young, motivated patients	o Patient age: >40 years	o Stable knee, ACL intact – partial meniscectomy in non-repairable cases only if lesion is symptomatic		o Stable lesions (medial or lateral meniscus) post ACL reconstruction – no surgery preferred
	o Timing: recent lesion	o Tear type: non-traumatic degenerative meniscal lesions	o Meniscal tear with reconstructed ACL – partial meniscectomy in non-repairable cases		o Meniscal repair on non-reconstructed knee is debatable
	o Tear location: peripheral vascularised area, lateral meniscus	o Tear location: avascularised white-white zones, medial meniscus tears – partial meniscectomy preferred	o Meniscal tear with non-reconstructed ACL – meniscectomy recommended if the following criteria are met:		o In peripheral lesions, the alternative to repair is total or subtotal meniscectomy of the segments concerned. However, this damages the
	o Unstable peripheral meniscal lesions (mostly medial meniscus) post ACL reconstruction		o symptomatic meniscal lesion		cartilage
			o irreparable meniscal lesion		
			o absence of functional instability		
			o relatively inactive or elderly patient		

BASK, UK [1]	o Repair considered for acute injury with meniscal target confirmed by MRI	o Advanced structural OA	o Meniscal target (imaged using MRI) and corresponding symptoms >3 months – consider non-urgent arthroscopic partial meniscectomy		o Recommendation not provided for management of specific tear types
		o Locked knee	o Possible meniscal target (imaged using MRI) and corresponding symptoms – non-operative treatment and re-assess		o Advanced structural OA – no arthroscopic meniscal surgery
JOA, Japan [12]	o ACL and meniscus injury – meniscal repair is recommended due to the possibility that meniscectomy will accelerate progression of OA			o Risk of OA progression	
NOV, the Netherlands [32]	o Patient age: younger patients with a lateral meniscal injury			o Always consider meniscal repair or follow a wait-and-see policy. Meniscal injury does not necessarily mean meniscectomy	Degenerative meniscus injury:
	o Tear location: tear close to or separated from the knee joint capsule, or a longitudinal tear in the peripheral part of the red-red zone, provided that the torn meniscus tissue is of good quality and the knee is stable (or an unstable knee that is stabilised within 6 weeks)			o Leave the peripheral rim of the meniscus intact	o Start with nonoperative treatment in degenerative meniscus injury
	o Tear type: bucket-handle tear in combination with ACL rupture			o Lateral meniscus injury in younger patients	o Consider treating nonoperatively for at least 3 months in the event of a meniscal tear



Position statement of the AAC, Canada [33]	o Preservation of the medial and lateral meniscus by repair of the body or root			o For patients with a degenerative medial meniscal tear and minimal to no OA, the majority will respond to non-operative intervention and will not likely require arthroscopic medial meniscectomy
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**Table 2:** Clinical guidelines on meniscal repair: eligibility criteria and considerations.

**Abbreviations:** AAC: Arthroscopy Association of Canada; AAOS: American Academy of Orthopaedic Surgeons; ACL: anterior cruciate ligament; BASK: British Association for Surgery of the Knee; BMI: body mass index; ESSKA: European Society for Sports Traumatology, Knee Surgery and Arthroscopy; HAS: Haute Autorité de Santé; JOA: Japanese Orthopaedic Association; MRI: magnetic resonance imaging; NOV: Nederlandse Orthopaedische Vereniging; OA: osteoarthritis; UK: United Kingdom; US: United States.

### Meniscal surgery procedure volume trends

Nine published sources covering France [1], Japan (n=2) [24,25], the Netherlands [26], UK [27] and US (n=4) [17, 28-30] were identified (Table 3–5); no real-world data from Canada or Europe as a whole were identified. Only five studies specifically reported procedure volume trends, from France [1], Japan (n=2) [24,25], the Netherlands [26] and US [28] (Table 3-4). Data sources included governmental bodies, national insurance databases and observational datasets; studies focused on indications including meniscal repair, meniscectomy, ACL reconstruction and ACL reconstruction with repair. The registry-based data analysed in the Netherlands study did not discern between meniscectomy and repair. An overview of meniscal repair trends is shown in Table 3, and a summary of data extracted from each study in Table 4. Overall, the total number of repair procedures increased clearly across all geographies between 2004–2017 (Table 3); in three studies this resulted in a significant increase in the proportion of meniscus repairs at the expense of meniscectomies (France [1], Japan [n=2] [24,25]). In Japan, the proportion of meniscus repairs significantly increased between 2007 and 2015, from 7.0% to 25.9%; the proportion of meniscectomies decreased accordingly over the same period (92.8% to 73.3%) [25]. All five studies reported procedure trends by age, indicating that the proportion of injuries repaired increased across most age groups over the studied period. A similar rate of increase in meniscal repairs was reported across patients in all age groups between 20–70 years in France

[1] and Japan [24]. Although the increase in the rate of repair was similar across all age brackets, the reduction in meniscectomy appeared greatest in patients <40 years, whilst remaining stable in those >60 years (France) [1]. Notably, the proportion of injuries repaired decreased in the US for three age groups (35–44, 45–54 and 55–64 years) [28]. Despite the increase in meniscal repair procedures, the overall proportion of repairs versus meniscectomy still represented the minority of meniscal surgery procedures across all studies. Analyses of subgroups identified only one group — Japanese patients <30 years in 2014 (the final year included in the study) — where meniscal repair was the dominant procedure (50.3% of all meniscal surgical procedures) [25]. Three studies reported procedure trends by tear type (France [1], Japan [25], US [28]). One study conducted a subgroup analysis using patients <40 years and those >50 years, based on the assumption that traumatic and degenerative lesions are more prevalent in these subgroups, respectively; data indicated that the shift from meniscectomy to repair was particularly strong in patients <40 years, suffering from traumatic tears (France) [1]. Comparatively, the number of meniscectomies remained stable in patients >50 years, with predominantly degenerative tears (France) [1]. The proportion of patients undergoing repair increased significantly for those with lateral and medial tears, but with a greater increase in the former (Japan) [25]. Moreover, a greater increase in the number of repairs between 2005–2011 was observed when an ACL reconstruction was also performed (48.3%) compared to without (11.4%) (US) [28].

Study	Country	Time Series Start Date	Meniscal Repairs at the start of the time series <sup>a</sup>	Time Series End Date	Meniscal Repairs at the end of the time series <sup>a</sup>	Trend	P-Value
Abrams et al., 2013	US	2005	3197/year	2011	3561/year	↑	P=0.001
Jacquet et al., 2019	France	2005	0.42/10,000 inhabitants	2017	1.36/10,000 inhabitants	↑	P<0.0001
Katano et al., 2018	Japan	2011	Meniscus repair ratio: <sup>b</sup> 9%	2016	Meniscus repair ratio: <sup>b</sup> 25%	↑	P=0.0008
Kawata et al., 2018	Japan	2007	Proportion undergoing repair: <sup>c</sup> 7%	2014	Proportion undergoing repair: <sup>c</sup> 25.9%	↑	P<0.001

Table 3: Overview of volume trends in meniscal repair procedures. <sup>a</sup> The volume of meniscal repairs is listed as reported in each individual study.

<sup>b</sup> The proportion of total meniscal surgeries including: (i) meniscectomy and (ii) meniscus repair.

<sup>c</sup> The proportion of total meniscal surgeries including: (i) meniscectomy, (ii) meniscus repair, and (iii) both meniscectomy and repair.

**Abbreviations.** US: United States.

Study	Country	Data Source	Summary of Meniscal Repair Trend	Reports Trend by:	
				Age (yes/no)	Tear type (yes/no)
Abrams et al., 2013	US	PearlDiver Patient Record Database (2005–2011)	<ul style="list-style-type: none"> <li>○ Patients grouped by type of surgery (just meniscectomy, just repair, repair then meniscectomy, ACL reconstruction with linked repair, and finally ACL reconstruction with linked repair then later a meniscectomy)</li> <li>○ There was a significant increase in the total number of meniscus repairs performed in the US from 2005 to 2011 (3,196/year vs 3,561/year), and doubling in incidence (100%)</li> <li>○ There was no significant increase in the total number of meniscectomies performed over the same time frame (51,699/year vs 54,109/year), with an increase in incidence of only 14%</li> <li>○ There was an 11.4% increase in the total number of meniscus repairs in the setting of an isolated meniscus tear, while the rate of repairs increased 48.3% when an ACL reconstruction</li> <li>○ Data suggest meniscus repairs are being chosen over meniscectomy</li> </ul>	Yes	Yes

<p>Jacquet et al., 2020</p>	<p>France</p>	<p>French Agency for Information on Hospital Care (2005–2017)</p>	<ul style="list-style-type: none"> <li>○ 1,564,461 meniscectomies and 63,142 repairs were done in France over the specified period</li> <li>○ Large regional differences: regions in Eastern France had higher meniscectomy rates, while regions in Western France had higher repair rates</li> <li>○ The meniscectomy rate gradually decreased from 19.80/10,000 inhabitants in 2005 to 15.77/10,000 inhabitants in 2017 (21.4% reduction)</li> <li>○ Meniscus repair rate increased from 0.42/10,000 inhabitants in 2005 to 1.36/10,000 inhabitants in 2017 (320% increase)</li> <li>○ A larger meniscectomy reduction effort occurred in private sector hospitals between 2005 and 2017 (15.79 to 12.01/10,000) than in public hospitals (4.01 to 3.77/10,000 inhabitants), causing a greater increase in the meniscus repair/meniscectomy ratio in public hospitals (4% to 12.6%) than in private hospitals (1.6% to 6.6%) in the same 12-year period</li> <li>○ When the analysis of procedures between 2008 and 2017 was stratified by age, a similar increase in repair procedures was found in all age brackets</li> <li>○ The reduction in meniscectomy was most apparent before 40 years of age, and the number of meniscectomy procedures was stable after 60 years of age</li> <li>○ When patients were analysed in two subgroups (&lt;40 years and &gt;50 years) according to tear type (traumatic and degenerative, respectively) data suggested that the shift from meniscectomy to repair was particularly valid in those under 40 years</li> </ul>	<p>Yes</p>	<p>Yes</p>
<p>Katano et al., 2018</p>	<p>Japan</p>	<ul style="list-style-type: none"> <li>○ The National Database of Health and Insurance Claims and Specific Health Checkups of Japan (2014–2015)</li> <li>○ Statistics of Medical Care Activities in Public Health Insurance (2011–2016)</li> </ul>	<ul style="list-style-type: none"> <li>○ Focused only on meniscus surgeries, no ACL or other knee surgeries</li> <li>○ The ratio of meniscus repair surgeries versus meniscectomy increased in both databases over the studied time periods (National Database: 19% in 2014 to 24% in 2015; Statistics of Medical Care Activities: from 9% in 2011 to 25% in 2016)</li> <li>○ The meniscus repair ratio also increased significantly in each age group between the early 20s and late 70s; peak ages for the Statistics of Medical Care Activities were for patients in their 60s (highest) and late teens (2<sup>nd</sup> highest), similar to the National Database</li> </ul>	<p>Yes</p>	<p>No</p>

Kawata et al., 2018	Japan	Diagnosis Procedure Combination database (2007–2015)	<ul style="list-style-type: none"> <li>○ 69,310 (83.4%) people had meniscectomy, 13,416 (16.1%) had repair and 379 (0.5%) had both</li> <li>○ The proportion of patients having meniscal repair (opposed to meniscectomy) significantly increased from 7.0% in 2007 to 25.9% in 2014, whilst the proportion of patients having meniscectomy decreased from 92.8% to 73.3% over the same period</li> <li>○ Meniscus repair is being increasingly favoured at the expense of meniscectomy             <ul style="list-style-type: none"> <li>○ Out of the total number of meniscal surgeries in patients under 30 years old in 2014, the amount of meniscal repair versus meniscectomy was 50.3% versus 48.3%</li> <li>○ The proportions of patients undergoing meniscus repair showed significant increases in both lateral and medial tears (with a greater increase in the former); the same study found that the site of injury appeared to be influenced by age, with medial tears more common in 60–69 years of age and lateral in 10–19 years of age</li> </ul> </li> </ul>	Yes	Yes
Rongen et al., 2018	The Netherlands	Dutch national hospital basic care registrations (2005–2014)	<ul style="list-style-type: none"> <li>○ The number of meniscus surgeries was highest in patients aged 40–65 years (this age group made up for half of the general meniscal surgeries)</li> <li>○ The incidence of meniscus surgeries decreased from 2005 to 2014</li> <li>○ This occurred in all age groups, although the decrease was more pronounced for younger patients (&lt;40 years) compared to middle-aged and older patients (&gt;40 years)</li> <li>○ The application of nationwide guidelines for meniscus tears may have contributed to a decrease in rates of meniscus procedures</li> <li>○ Despite accumulating evidence that questions the justification and effectiveness of the treatment, meniscus surgery is still widely performed in the treatment of degenerative meniscus tears in the Netherlands</li> <li>○ This shows a lag in the dissemination, acceptance, and implementation of clinical evidence in practice in the Netherlands</li> </ul>	Yes	No

**Table 4:** Summary of studies on procedure trends.

**Abbreviations.** ACL: anterior cruciate ligament; US: United States.

## Discussion

In this review, seven guidelines from three continents were analysed for comparison with real-world data from clinical practice across the same geographies, using nine studies reporting procedural trends and/or relevant information regarding meniscal surgery. Between 2004–2017, the number of meniscus repair surgeries increased across all geographies. In the younger demographic, there was a concomitant decrease in the number of meniscectomies, causing an increase in the proportion of repair procedures out of all meniscal surgeries performed [1,17,24–30]. Real-world data were in line with guidelines favouring repair over meniscectomy for several target indications [7,18–20,22,23,31]. Nonetheless, the proportion of meniscectomies did not decrease uniformly in all geographies and/or age groups, and meniscal repair still represented the minority of all meniscal surgeries performed in all studies. This may be attributed to older patients who make up a significant proportion of meniscal injuries and are often considered poor candidates for repair [3]. Older patient age has traditionally been a reason to favour meniscectomy over repair, for example due to the shorter recovery time and higher rates of pre-existing OA in elderly patients [2,3,7–9,32]. Thus, meniscectomy is still being widely performed on degenerative tears in older patient groups. This practice is supported by some of the guideline recommendations. Since results demonstrate that meniscal repair is rising, but to a lesser extent than guidelines recommend, further research is warranted to understand whether this is attributable to a lack of surgical consensus on the recommendations or a conscious deviation from best practice recommendations for other reasons, which may include fiscal incentives put in place by reimbursement authorities [30].

### Short-term versus long-term benefits

Factors determining the feasibility of meniscal repair include tear vascularity and location, patient age and the presence of OA [2]. One major distinction between meniscectomies and meniscal repairs is their effectiveness in providing short- versus long-term benefits. Although repair requires a longer recovery period, the procedure ensures maximal preservation of the meniscus thereby reducing the risk of OA and Total Knee Arthroplasty (TKA) [8,9,10,12,19,22,33]. In line with the guidelines and procedure trends analysed in this review, a 2015 meta-analysis investigating differences in short- and long-term surgical outcomes (based on International Knee Documentation Committee Score, Lysholm Score, Tegner Score and failure rates), found that meniscal repair is associated with better long-term patient-reported outcomes and activity levels compared with meniscectomy [34]. Although the shorter recovery period and decreased risk of surgical complications make meniscectomy more economically attractive in the short-term, the reduced risk of re-operation, OA and TKA with meniscal repair contribute to its superior long-term cost-

effectiveness. One study reported that the average total cost of surgery was significantly higher per patient for meniscal repair (\$7,094) compared with meniscectomy (\$5,423) (US) [15]. However, a 10-year meta-analysis indicated that when considering long-term outcomes, meniscal repair is the lowest cost strategy (\$22,590 compared with \$31,528 for meniscectomy); this was largely due to significantly lower rates of post-operative OA and TKA (US) [18]. The degree to which this influences surgical decision-making is unclear and may depend on the time horizon of the economic decision-maker.

### Limitations

This review aimed to compare guidelines and procedure volumes from a selection of countries and was not intended to be a fully systematic analysis. The guidelines analysed were variable in their specificity to meniscus injury and the specificity of the recommendations on repair and resection. Furthermore, recommendations relating to specific tear types and age groups were often limited or unclear. This may explain some of the practice deviation, therefore updates of guidelines to capture the latest evidence on meniscal repair techniques and provide more detailed recommendations on tear types may be warranted. Procedure volume trends were reported across studies using different measurements; whilst a comparison of the trends between geographies was beyond the scope of this review, exploring regional differences in clinical guideline adherence, and potential causes of this, provides an interesting avenue for future research. Whilst the overall timeframe covered by the procedure volume data spans 2004–2017, individual studies covered different parts of this timeframe and the different time periods analysed may further explain some of the differences in procedural trends. For example, whilst the US-based study by Abrams et al., had the largest sample size (>22 million people each year), the analysed data covered 2005–2011, and may be a poor reflection of the latest techniques used in current practice [13]. More recent data are required to elucidate whether clinical practice has continued to favour meniscal repair over meniscectomy, as recommended by respective guidelines. Recent advances in repair devices have improved post-operative outcomes and reduced the rate of repeat surgery, enabling surgeons to repair more complex tears that previously necessitated meniscectomy [12]. Further investigation into the impact of these techniques and their position in guidelines for the surgical management of meniscal tears should be explored.

This review was limited by the selection criteria used, which was confined to publications in English and to procedural volume data from countries with identified guidelines; the included studies therefore represent a small proportion of available data on meniscal surgery. Data spanning a greater range of countries are needed to fully understand the extent to which clinical guidelines are being followed in practice. Moreover, further analysis of potential

variables influencing the choice of surgical approach would be beneficial. For example, data from France identified differences in procedure trends between private and public hospitals, and between different regions within France [1]. This research may allow the factors contributing to treatment guideline adherence to be elucidated. This review has highlighted that real-world evidence stratifying procedural volume data by meniscal tear type is lacking, despite being a key consideration discussed in guidelines when determining the appropriate meniscal procedure. Therefore, evidenced conclusions regarding adherence to guidelines for specific tear types are limited in this review.

## Conclusions

Trends in surgical management of meniscal tears in clinical practice overall demonstrate an increased adherence to the identified guidelines. In line with the increasing emphasis on meniscal repair versus meniscectomy, real-world data indicate that surgeons are increasingly favouring repairs in the studied populations between 2005–2017. However, meniscectomy remains the dominant meniscal surgical procedure, contrasting with the importance of meniscal preservation emphasised in guidelines. Review of guidelines is encouraged to consider how this can be addressed, focusing on the role of meniscal repair in older patients and those with more complex tears, to ensure all patients receive the appropriate surgical management to improve their function and long-term clinical outcomes.

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