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Pengas, Ioannis

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Ioannis Pengas

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Total meniscectomy in adolescents

A 40-YEAR FOLLOW-UP

I. P. Pengas,
A. Assiotis,
W. Nash,
J. Hatcher,
J. Banks,
M. J. McNicholas

From Ninewells Hospital, Dundee, United Kingdom

■ I. P. Pengas, MBChB, MRCS, MPhil, Specialist Registrar in Trauma and Orthopaedics
Percivall Pott Rotation, Great Ormond Street Hospital, Great Ormond Street, London WC1N 3JH, UK.

■ A. Assiotis, MBBS, MSc, MRCS, Specialist Registrar in Trauma and Orthopaedics
Milton Keynes Hospital, Standing Way, Eaglestone, Milton Keynes, Buckinghamshire MK6 5LD, UK.

■ W. Nash, MBBS, MRCS, BEng, Specialist Registrar in Trauma and Orthopaedics
SE Thames Rotation, Queen Elizabeth Hospital, Stadium Road, Woolwich, London SE18 4QH, UK.

■ J. Hatcher, MCSP FOM CSCS, MPhil, Senior Lecturer
University of Salford, Directorate of Sport, Exercise & Physiotherapy, School of Health Sciences, Frederick Road Campus, Manchester M6 6PU, UK.

■ J. Banks, MBChB, MSc(Orth Eng), FRCSEd(Tr & Orth), Consultant Orthopaedic and Trauma Surgeon
Royal Liverpool & Broadgreen University Hospitals NHS Trust, Prescot Street, Liverpool L7 8XP, UK.

■ M. J. McNicholas, FRCSEd(Tr & Orth), MD, Consultant Trauma and Orthopaedic Soft-Tissue Knee Surgeon, University Hospital Aintree Teaching Hospital NHS Foundation Trust, Major Trauma Centre, Longmoor Lane, Liverpool L9 7AL, UK.

Correspondence should be sent to Mr I. P. Pengas; e-mail: yiannispengas@yahoo.com

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We continued a prospective longitudinal follow-up study of 53 remaining patients who underwent open total meniscectomy as adolescents and who at that time had no other intra-articular pathology of the knee. Their clinical, radiological and patient-reported outcomes are described at a mean follow-up of 40 years (33 to 50). The cohort of patients who had undergone radiological evaluation previously after 30 years were invited for clinical examination, radiological evaluation and review using two patient-reported outcome measures.

A total of seven patients (13.2%) had already undergone total knee replacement at the time of follow-up. A significant difference was observed between the operated and non-operated knee in terms of range of movement and osteoarthritis of the tibiofemoral joint, indicating a greater than fourfold relative risk of osteoarthritis at 40 years post-operatively. All patients were symptomatic as defined by the Knee Injury and Osteoarthritis Outcome Score.

This study represents the longest follow-up to date and it can be concluded that meniscectomy leads to symptomatic osteoarthritis of the knee later in life, with a resultant 132-fold increase in the rate of total knee replacement in comparison to their geographical and age-matched peers.

The incidence of meniscectomy in the general population is reported to be 61 in 100 000 per year.[1] The menisci share load, attenuate shock and provide secondary stability to the knee.[2-5] They also contribute to proprioception, joint lubrication and nutrition of articular cartilage through the facilitation of synovial fluid flow.[6-8] Their importance to the integrity of the knee is acknowledged by the shift towards attempted repair and more recently meniscal replacement rather than debridement or excision.[9,10]

Several authors have reported that partial or total meniscectomy has detrimental effects and leads to radiological evidence of osteoarthritis (OA) of the knee in up to 50% of patients between five and 15 years post-operatively.[11-13] Unfortunately variable inclusion and exclusion criteria, inconsistent reporting on coexisting pathology within the knee and a lack in standardised means of data collection and analysis, are factors that make drawing firm conclusions difficult.[14,15]

This paper examines the long-term follow-up of a cohort of patients who underwent open total meniscectomy and who have been studied at intermittent periods subsequently.

Patients and Methods

Under the care of Professor Iain Smillie, 313 adolescent patients underwent open total meniscectomy in the 1960s and 1970s. Of those patients, 100 who were confidently identified as having no other intra-articular knee pathology at the time of operation were reviewed at 17 years and 30 years post-operatively when both knees were evaluated radiologically.[16,17] Inevitably patients have been lost to follow-up or excluded. The study, which had ethical approval, represents the ongoing follow-up of 53 patients at a mean of 40 years (33 to 50 years). At the time of review five patients had died, seven had undergone a total knee replacement (TKR), six were lost to follow-up, three declined to be assessed and one was unable to attend due to multiple sclerosis (Fig. 1). In addition, one female patient who underwent lateral meniscectomy was unable to attend the clinic and completed the patient-related outcome measures (PROMs) questionnaires over the telephone; their data were excluded from subsequent statistical analysis (Table I).[18] A total of 30 patients therefore had objective and PROMs recorded at dedicated clinics. Eight patients had subsequently undergone

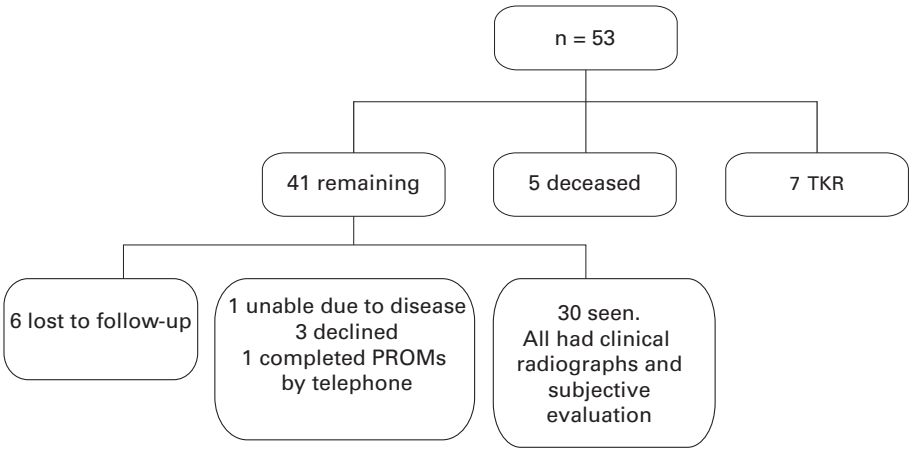

Fig. 1

Flow chart showing the patients that participated in the 40-year follow-up (TKR, total knee replacement; PROMs, patient-reported outcome measures).

Table I. Patient demographics

Sample population	Whole cohort (n = 31)	Male (n = 25)	Female (n = 6)
Mean age at meniscectomy (yrs) (range)	15.6 (10 to 19)		
Mean age at assessment (yrs) (range)	56.5 (43 to 67)		
Mean body mass index at assessment (kg/m^2) (range)	28.3 (21.8 to 37.6)		
Type of meniscectomy (n, %)			
Unilateral medial	9 (*29*)	7 (*28*)	2 (*33*)
Unilateral lateral	8 (*26*)	7 (*28*)	1 (*17*)*
Unilateral medial and lateral	6 (*19*)	5 (*20*)	1 (*17*)
Bilateral medial	3 (*10*)	3 (*12*)	0 (*0*)
Bilateral lateral	4 (*13*)	3 (*12*)	1 (*17*)
Bilateral medial and lateral	1 (*3*)	0 (*0*)	1 (*17*)

* this patient was excluded from further analysis after completing the questionnaire over the telephone only

interventions involving the contralateral knee after their 19th birthday; thus the number of patients who had an intervention on one knee only at the time of review was 22.

All patients were reviewed by one assessor (IP), who recorded the range of movement (ROM) in both knees using of a long-levered goniometer and anterior tibial translation (sagittal laxity) with the use of the Rolimeter device (DJO, Vista, California) by averaging three consecutive readings of each parameter. Outcomes were assessed using the International Knee Documentation Committee (IKDC)[19,20] and Knee Injury and Osteoarthritis Outcome (KOOS) scores.[21]

Anteroposterior weight-bearing radiographs of both knees were made with the knee in 15° of flexion and were subsequently randomly reviewed and scored independently by two assessors (IP, AA) who were blinded as to whether the knee being analysed had had a meniscectomy or not. The radiographs were analysed in darkened rooms and from the set distance of 60 cm without magnifying equipment, using the scoring systems of Ahlbäck[22] and Kellgren and Lawrence[23] (Table II).

Statistical analysis. The data were analysed with SPSS 17.0 (SPSS Inc., Chicago, Illinois) statistical package where a p-value of < 0.05 was defined as statistically significant. Data were examined for normality using the Shapiro-Wilk test. Parametric data were analysed using the *t*-test, and for non-parametric data the Wilcoxon signed-rank test and the Mann-Whitney U test were used. Correlations were scrutinised with the Kendall's tau coefficient.

Results

Seven patients had undergone TKR, giving a rate of 13.2% at a mean of 40 years post-operatively. A rate of TKR of 0.1% was recorded in an age-matched regional population in the Scottish Arthroplasty Register in 2008,[24] which is similar to the rate reported in other arthroplasty registries.[25] This therefore represents a 132-fold increase in the frequency of TKR in patients who had had a total open meniscectomy.

Table II. Ahlbäck[22] and Kellgren and Lawrence[23] radiological scoring systems for osteoarthritis

Grade	Definition
Ahlbäck grade	
Grade I	Joint space narrowing (< 3 mm)
Grade II	Joint space obliteration
Grade III	Minor bone attrition (0 mm to 5 mm)
Grade IV	Moderate bone attrition (5 mm to 10 mm)
Grade V	Severe bone attrition (> 10 mm)
Kellgren & Lawrence	
Grade 1	Minute osteophyte
Grade 2	Definite osteophyte; unimpaired joint space
Grade 3	Moderate diminution of joint space
Grade 4	Joint space greatly impaired with sclerosis of subchondral bone

Table III. Radiological scores, range of movement and International Knee Documentation Committee (IKDC) scores by site of meniscectomy

		Site of meniscectomy			
Outcome	**All knees**	**Medial (n = 9)**	**Lateral (n = 7)**	**Medial & lateral (n = 6)**	**p-value***
Median radiological score					
Kellgren & Lawrence	3	3	3	3	0.099
Ahlbäck	1	0	1	1	0.22
Mean flexion (°) (SD)	126.0 (11.6)	120.7 (14.8)	132.9 (8.1)	121.0 (7.4)	0.057
Hyperextension (°) (SD)	-5.2 (6.6)	-5.7 (5.3)	-2.1 (7.0)	-8.0 (8.4)	
Mean IKDC (SD)	62.3 (11.25)	59.6 (10.9)	69.3 (9.4)	57.7 (11.3)	0.163

* Kruskal-Wallis test

The outcomes of the 22 patients that underwent unilateral meniscectomy are outlined below. There were 19 males and three females; nine had medial meniscectomy, seven lateral and six both medial and lateral meniscectomies. The mean age at surgery was 15.4 years (10 to 18) and their mean BMI at review was 28.7 kg/m^2 (21.8 to 37.6).

The outcome for patients as per site of meniscectomy was tested against both radiological scoring systems,[22,23] ROM and IKDC score, and all were shown to be non-significant (Table III). Based on these findings, the group of patients who had surgery solely on one knee could be considered as a whole and compared with the contralateral non-operated knee.

Sagittal laxity was assessed between the operated and non-operated knees; no statistically significant difference was found when measured at either 30° ($p = 0.475$) or 90° ($p = 0.585$) (Table IV). However the ROM was generally reduced in the operated knee, and there was a small increase in fixed flexion when compared to the non-operated side (Table IV).

The two different methods of radiological analysis correlated well (Kendall's tau $\tau = 0.850$, $p < 0.001$) (Table IV).

Petersson et al[26] have defined evidence of OA as Kellgren and Lawrence grade ≥ 2 and Ahlbäck grade ≥ 1. The incidence of knees demonstrating OA according to Kellgren and Lawrence was 81% and Ahlbäck 77.2%, whereas in the non-operated knees this was 18% for both systems (Table IV). This suggests that the relative risk (RR) of OA development in this cohort is 4.5 (95% confidence interval (CI) 1.8 to 11.2) for Kellgren and Lawrence and 4.25 (95% CI.1.7 to 10.6) for Ahlbäck. The degree of radiological OA in the tibiofemoral joint was significantly different between the operated and the non-operated knee (Wilcoxon signed rank test, $p < 0.001$).

The mean IKDC score for the 22 unilateral patients was 62.3 (40.2 to 81.6) and the mean KOOS score was 70.5 (14.3 to 100.0). The mean subscores concerning pain, activities of daily living, sport and quality of life are given in Table V. Taking into account the symptomatic KOOS scores as defined by Englund, Roos and Lohmander,[27] it is evident that this cohort of patients are symptomatic in all categories (Table V).

The Kendall's tau coefficient demonstrated a moderate but statistically significant inverse correlation between the Ahlbäck radiological score and the IKDC, KOOS sport and KOOS activities of daily living scores ($p = 0.009$, $p = 0.044$ and $p = 0.010$, respectively). There was also a statistically significant negative correlation between radiological OA scores and ROM ($\tau = -0.61$).

Table IV. Sagittal laxity, range of movement (ROM), and radiological osteoarthritis scores compared between the operated and non-operated knees

	Operated knee	Non-operated knee	p-value
Mean sagittal laxity (mm) (range)			
At 30°	5.50 (3 to 9)	4.37 (1 to 8.33)	0.475
At 90°	5.18 (1.67 to 11)	4.18 (2 to 8.33)	0.585
Mean ROM measurements (°) (range)			
ROM	120 (75 to 150)	135 (90 to 150)	
Fixed flexion (-)/hyperextension (+)	-5.45 (-15 to 10)	+2.7 (-10 to 10)	
Maximum flexion	125.4 (90 to 140)	132.9 (100 to 140)	
Median Ahlbäck grade[22]	1	0	
Median Kellgren & Lawrence grade[23]	3	1	
Knees with evidence of osteoarthritis (n, %)			
Ahlbäck grade ≥ 1	17 (*77*)	4 (*18*)	
Kellgren & Lawrence grade ≥ 2	18 (*81*)	4 (*18*)	

Table V. The mean Knee Injury and Osteoarthritis Outcome Scores (KOOS) in our cohort and by unilateral/bilateral procedure, and compared with those KOOS values defined as 'symptomatic' by Englund, Roos and Lohmander[27]

KOOS subscale	'Symptomatic' score	Whole group (n = 30)	Unilateral group (n = 22)	Bilateral group (n = 8)
Symptoms	86.1	65.5	70.45 (14.3 to 100.0)	54.9 (35.7 to 78.5)
Pain	85.7	74.4	78.28 (38.9 to 100.0)	66.3 (33.3 to 94.4)
Activities of daily living	86.8	79.1	82.20 (50.0 to 100.0)	72.6 (45.5 to 100)
Sport	85.0	62.6	67.27 (40.0 to 100.0)	51.9 (5 to 100)
Quality of life	87.5	65.3	70.45 (18.8 to 100.0)	47.7 (25 to 100)

Discussion

Fairbank[28] was the first to report the radiological changes after meniscectomy with Tapper and Hoover[29] devising a scoring system as an assessment of patient satisfaction.

Meniscectomy studies, total or partial, open or arthroscopic, short-term or long-term, indicate that there is the subsequent development of OA to varying degrees (Table IV).[13,15,29-36] We found an apparent 132-fold increase in the incidence of TKR in patients who had open total meniscectomy, when compared with an age-matched population from the same area. We accept that this figure needs to be interpreted with caution as numbers are small.

It is unclear whether degenerative arthritis is more likely to follow total medial or lateral meniscectomy. Some authors have reported that patients who had a lateral meniscectomy fared worse than those who had a medial meniscectomy,[17,35,37] whereas others did not find any difference.[38-41] We concluded that the site of meniscectomy did not affect the radiological, clinical or functional outcomes, although the cohort is small.

Previous long-term studies perhaps failed to demonstrate a relationship between any resultant knee OA and PROMs, due to the utilisation of outcome scoring systems that were unable to reflect the true picture, such as the Tapper and Hoover system.[42] With the use of two independent patient-reported scoring systems, that have been shown to be reliable and valid,[43] we demonstrated that all of our patients were to some degree symptomatic[27] and their symptoms correlated with the degree of OA radiologically as per IKDC.

Unfortunately, after this period of time many patients are inevitably lost to follow-up, although in our series this is less than in other long-term studies.[15] The lack of a healthy age, gender and race-matched control group,[15] left us relying on the non-operated contralateral knee as a control, as other authors have done.[16,17,44-46] In our patients, further surgery on the contralateral knee resulted in the exclusion of those with bilateral knee meniscectomies (n = 8) from comparative analysis; this is also not a new phenomenon in long-term follow-up studies.[27,32,45]

Whilst other studies may have reported on greater numbers, some did so based on a non-uniform cohort and others on shorter follow-up (Table VI). The uniqueness of this study not only lies in the length of follow-up but also in the specific characteristics of the patients in that they were young at the time of the initial procedure and were known to have an otherwise normal knee. They also underwent a standardised operative technique carried out by an acknowledged pioneering expert at that time and a protocol driven post-operative rehabilitation.

When Professor Smillie pioneered total meniscectomy, he proposed (albeit erroneously, as we now know) that the meniscus might regenerate.[47,48] Improvement in satisfaction was noted between the two previous follow-ups of this cohort despite observing radiological deterioration.[16,17] This long-term follow-up confirms the findings of the previous studies in that it appears that over time the development of OA is almost certain with a relative risk of 4.25 as per Ahlbäck and 4.5 as per Kellgren and Lawrence.

Table VI. Studies examining effects of total *versus* partial, open *vs* arthroscopic meniscectomy (OA, osteoarthritis)

Author/s	Number	Mean follow-up (yrs)	Type of meniscectomy	Conclusions
Jackson[34]	577	> 5	Open total	Loss of meniscus probable cause for observed degenerative changes
Tapper and Hoover[29]	213	10 to 30	Open total *vs* open partial	Partial fares better than total only in bucket-handle tears
Johnson et al[35]	99	17.5	Open total	High incidence of degenerative changes after meniscectomy
McGinity et al[31]	128	5.6	Arthroscopic partial *vs* arthroscopic total	Partial is best choice for properly selected tears
Northmore-Ball et al[33]	219	4.3	Arthroscopic partial *vs* open partial *vs* open total	Arthroscopic partial is the treatment of choice
Hede et al[13]	192	7.8 (median)	Arthroscopic partial *vs* arthroscopic total	Better knee function after partial
Roos et al[15]	123	21	Open total (*vs* matched controls)	Meniscectomy is significant risk for tibiofemoral OA
Hoser et al[30]	31	10.3	Arthroscopic partial lateral	High incidence of degenerative changes and poor function
Andersson-Molina et al[36]	36	14	Arthroscopic total and partial	More radiological changes in total meniscectomy group
Englund and Lohmander[32]	317	18	Open/arthroscopic and total/partial	Total meniscectomy associated with more radiological evidence of OA

Where perhaps other studies observed 'unimpressive' symptomatology, here the whole cohort's recorded outcomes were deemed symptomatic as per the KOOS. Furthermore, the degree of observed osteoarthritis correlated with PROMs as per IKDC and loss of function as per range of motion, leading to an 132-fold increased rate of definitive intervention in the form of total knee arthroplasty years earlier than their ethnically, geographically and age-matched peers.

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