Prevalence of osteoarthritis and clinical results after the Elmslie-Trillat procedure: a retrospective long-term follow-up

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Abstract

Purpose Tibial tuberosity medialisation may be followed by osteoarthritis in the long term due to increased patellofemoral contact pressure and altered knee joint kinematics. We aimed to (1) systematically assess the grades of tibiofemoral and patellofemoral osteoarthritis ten to 30 years after the Elmslie-Trillat procedure and (2) to evaluate long-term knee function and activities of daily living.

Methods A total of 26 patients (30 knees) were re-evaluated at a minimum follow-up of 12.3 years (mean 20.9 ± 4.1 years). Osteoarthritis was graded according to Kellgren and Lawrence (K/L) and Sperner. All patients were clinically evaluated using the Knee Society Score (KSS) and Knee injury and Osteoarthritis Outcome Score (KOOS). Radiographic data were compared to an age-, sex- and body mass index-matched control group of healthy patients.

Results Radiographic evaluation revealed seven cases (23.3 %) with advanced osteoarthritis (K/L and Sperner grades 3 and 4). However, the observed differences from the matched cohort were not statistically significant ($P=0.189$). A positive correlation was found between the age at index procedure and

tibiofemoral osteoarthritis at follow-up ($P=0.013$). Patient satisfaction was relatively high, showing a mean KSS of 89.9 (knee score) and 94.8 (function score), and a mean KOOS of 78.7. However, we noted four cases of frequent patellar re-dislocations and three total knee arthroplasties.

Conclusions The Elmslie-Trillat procedure was associated with several cases of advanced tibiofemoral and patellofemoral osteoarthritis in the long term, especially if the procedure was performed late. Clinical results were still good to excellent in the majority of patients despite some observed cases of re-dislocations and decreased ability to perform sports.

Keywords Elmslie-Trillat procedure · Tibial tuberosity medialisation · Patellar dislocation · Osteoarthritis · Joint kinematics

Introduction

Recurrent patellar dislocations in children and adolescents may cause devastating sequelae in terms of pain, clinical impairment and osteoarthritis in the long term [1–3]. While an initial, traumatic patellar dislocation might be appropriately treated by conservative means, recurrent dislocations necessitate surgical therapy to restore anatomic patellar tracking, correct limb alignment and rotation [4]. Numerous proximal and distal realignment procedures have thus been described to improve the knee extensor mechanism [4–7]. The Elmslie-Trillat procedure is a distal bony realignment procedure involving medialisation of the tibial tuberosity, lateral retinacular release and medial capsular reefing [8, 9].

Several studies have documented clinical short- to long-term results of this established procedure and its modifications revealing good and excellent functional results in most investigations [10–14]. However, the long-term benefit with respect to osteoarthritic changes of the operated knee joint is still

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unknown. Although it has been shown that operatively treated knees are associated with a lower risk of recurrent dislocations, they may bear a higher risk of subsequent patellofemoral joint degeneration [15, 16]. Late osteoarthritis is therefore considered to be an impending risk of this surgical technique due to increased patellofemoral contact pressure and changes of knee joint loading [17–19].

The aim of this study was therefore (1) to systematically assess the grades of tibiofemoral and patellofemoral osteoarthritis ten to 30 years after the Elmslie-Trillat procedure and to compare them to an otherwise healthy age-, sex- and body mass index (BMI)-matched control group, and (2) to evaluate long-term knee function and activities of daily living after the index procedure.

Patients and methods

Patient selection

This study was designed as a retrospective case-control study (Level III) with a single follow-up visit of the study cohort. Institutional Review Board (IRB) approval was obtained prior to data acquisition. The hospital's database was manually screened for patients undergoing the Elmslie-Trillat procedure for recurrent patellar dislocation between 1981 and 2001 in order to provide a minimum follow-up of ten years. After extraction of appropriate data, patients were contacted via letter and asked for a single re-evaluation of their current knee status. Those who did not respond to our letter were again contacted via letter six weeks later in order to maximise the sample size. Furthermore, a phone inquiry was performed after a total of 12 weeks to ask for a short comment on their knee status after the above-mentioned procedure. Inclusion criteria were patients with recurrent patellar dislocations (>2) in childhood and/or adolescence, who underwent an Elmslie-Trillat procedure with or without concomitant diagnostic knee arthroscopy. Patients with additional soft tissue balancing (i.e. Krogus and Roux-Goldthwait procedures) and pregnant women were excluded. We were not able to recruit a control group of healthy volunteers due to regulations of the IRB. As a consequence, we decided on historic subjects to serve as an age-, sex- and BMI- matched control group. We searched our hospital data system for patients with no previous history of any patellar dislocation, undergoing radiographic knee evaluation between 2009 and 2011 in order to gather comparable radiographs.

Patient evaluation

All case cohort patients were both clinically and radiographically evaluated during a single visit in our hospital after informed consent was obtained. An independent investigator assessed demographic data (i.e. age, weight, BMI), post-

operative complications (re-dislocations, further surgery) and clinical parameters. Clinical data were organised using validated functional outcome scores [Knee Society Score (KSS) and Knee injury and Osteoarthritis Outcome Score (KOOS)], which were completed by the independent investigator (KSS) and participant (KOOS), respectively. While the KSS, comprising two sub-scores, primarily assesses pain, motion, alignment, stability (part 1: “knee score”) and gross function (part 2: “function score”), the KOOS is a more comprehensive tool for documentation of activities of daily living, recreational activities/sports and quality of life [20–22]. According to the KSS, a total outcome of 80–100 points was rated as “excellent”, 70–79 points as “good” 60–69 points as “fair” and a score below 60 points as “poor”.

Radiographic evaluation included (1) anteroposterior (AP) and (2) lateral (20° of flexion) weight-bearing radiographs of both knees, as well as (3) bilateral tangential patella radiographs (30° knee flexion). Thereafter, all radiographs of both groups were interpreted and rated by an independent investigator according to the following defined criteria: First, AP knee radiographs were evaluated with respect to any osteoarthritic change and graded according to Kellgren and Lawrence (K/L) in grades 0–4 [23]. Second, all tangential patella radiographs were evaluated regarding any patellofemoral osteoarthritis and graded according to Sperner (Fig. 1) [24]. We furthermore assessed the Insall-Salvati index, calculated based on the lateral knee radiographs, and Merchant's congruence angle, based on the tangential view radiographs. No preoperative radiographs were available for this study. However, thorough review of radiography documents revealed no cases of apparent preoperative joint degeneration.

In addition, we evaluated possible complications according to Goslings and Gouma as follows: 0 (no harm), 1 [temporary disadvantage, no (re-)operation], 2 [recovery after (re-)operation], 3 [(probably) permanent damage/disability], 4 (death) and 5 (unclear due to untimely death) [25]. Grades 4 and 5 of this classification were not applicable for this study due to its design with a single follow-up visit.

Demographic data

We considered a total number of 100 patients, who all met the relevant inclusion criteria after chart review, to be appropriate for inclusion. However, several patients who presumably relocated were untraceable. While 41 patients initially responded to our follow-up invitation, 26 patients (30 Elmslie procedures) were finally eligible for clinical and radiological follow-up, and nine patients for a phone survey. Overall, 25 female patients and one male patient were included in our case cohort. The mean age at re-evaluation of our patients was 51.0 years ($\pm$ 10.8 years, range 30.9–74.5 years). The mean follow-up period between operation and re-evaluation was 20.9 years ($\pm$ 4.1 years, range 12.3–28.7 years) with a minimum follow-up of 12.3 years (Table 1).

Fig. 1 Sperner classification of patellofemoral osteoarthritis: *grade 0* (no degenerative changes), *grade 1* (definitive subchondral sclerosis with minimal osteophytes on the patella), *grade 2* (definite osteophytes on the patella), *grade 3* (narrowing of patellofemoral joint space, osteophytes on the patella and femoral condyles) and *grade 4* (tight joint space and large osteophytes with a deformed patella) [24]

The case cohort was matched with regard to age, sex and BMI to a control group of 30 healthy patients of our data system.

Statistical analysis

The differences in baseline characteristics of both cohorts were assessed using paired *t* tests after data normality was confirmed by the Kolmogorov-Smirnov test. Furthermore, non-parametric data of both groups were compared using the sign test. Spearman rank correlation analysis was further used to calculate relevant correlations between continuous variables. A *P* value of <0.05 was considered significant for all aforementioned tests. All statistical calculations were performed with SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). In addition, we calculated post hoc power with respect to the magnitude of differences in outcome between both groups according to Hoenig and Heisey [26].

Table 1 Demographic details of study groups

Variable	Case group	Control group	<i>P</i>
Total procedures, <i>n</i>	30	30	
Patient characteristics			
Sex, male, <i>n</i>	1	1	
Sex, female, <i>n</i>	25	25	
Affected knee, left, <i>n</i>	17	13	
Affected knee, right, <i>n</i>	13	17	
Weight, kg	74.5 (48–115)	75.2 (50–120)	0.645
Height, cm	165.7 (152–178)	167.4 (156–178)	0.216
BMI, kg/m ²	27.1 (18.8–42.8)	26.8 (20.5–41.5)	0.745
Follow-up characteristics			
Age at procedure, years	30.1 (16.0–51.0)		
Age at re-evaluation, years	51.0 (30.9–74.5)	51.2 (32.6–75.5)	0.210
Follow-up period, years	20.9 (12.3–28.7)		

Data are expressed as mean (range) unless indicated otherwise

Results

Radiographic outcome

Radiographic evaluation of the case cohort revealed several knees with minimal, moderate and even severe tibiofemoral and patellofemoral osteoarthritis (Fig. 2). Overall, five patients (six knees, mean age 58.4 years) showed advanced grade 3 osteoarthritis, and one patient even grade 4 tibiofemoral cartilage degeneration according to K/L. In contrast, five patients (mean age 55.2 years) revealed grade 3 and two patients grade 4 patellofemoral osteoarthritis according to Sperner's classification. Although radiographic evaluation of the case group revealed more knees with advanced, higher graded osteoarthritis (K/L >2) compared to the matched control group, this was not significant on statistical analysis (*P*=0.189 for both scores) (Table 2). While Spearman's rank correlation revealed a positive and significant correlation between the age at index procedure and tibiofemoral osteoarthritis at follow-up (*r*=0.448, *P*=0.013), this test was not significant for patellofemoral osteoarthritis (*r*=0.333, *P*=0.073). Furthermore, no significant correlation between BMI at follow-up and presence of osteoarthritis was observed in our patients (*r*=0.228, *P*=0.226 and *r*=0.232, *P*=0.218, respectively).

Even with the modest sample size of 30 for the case group and 30 for the control group, the magnitude of differences of the Insall-Salvati index was large enough so that post hoc power analysis showed over 80 % power.

Clinical outcome

The KSS at the time of re-evaluation indicated high patient satisfaction with regard to motion and gross function. The mean KSS was 89.9 (± 12.0, part 1, knee score) and 94.8 (± 10.0, part 2, function score), respectively. Clinical outcome

Fig. 2 Distribution of tibiofemoral (K/L) and patellofemoral (Sperner) osteoarthritis observed in the case cohort

(KSS knee score) was rated as excellent in 25 cases (83 %), good in three cases (10 %) and fair in two cases (7 %), whereas functional outcome (KSS function score) revealed excellent results in 27 (90 %) and good results in three cases (10 %), respectively. Overall, no poor results were observed. The mean

KOOS at the time of re-evaluation was lower (78.7 ± 18.5), showing good results in terms of post-operative pain, daily living and overall quality of life but only fair results in the subcategory of sports/recreational activities (Table 3).

Table 2 Radiographic outcome of study groups

Outcome score	Case group	Control group	P
Kellgren-Lawrence (all cases)	1.70±0.99	1.20±0.71	0.189
Grade 0, n	2	4	
Grade 1, n	13	17	
Grade 2, n	8	8	
Grade 3, n	6	1	
Grade 4, n	1	0	
Kellgren-Lawrence (re-dislocation)			
Yes	1.67±0.82		
No	1.71±1.04		
P, between groups	0.625		
Sperner (all cases)	1.60±1.16	1.03±0.62	0.189
Grade 0, n	5	5	
Grade 1, n	11	19	
Grade 2, n	7	6	
Grade 3, n	5	0	
Grade 4, n	2	0	
Sperner (re-dislocation)			
Yes	1.17±0.75		
No	1.63±1.13		
P, between groups	0.375		
Insall-Salvati index	1.24±0.25	1.08±0.16	0.008
Merchant's angle, °	-6.55±20.99	-8.86±9.90	0.571

Data are expressed as mean ± standard deviation unless indicated otherwise

Complications

The following complications were observed in the 26 patients examined: six patients reported any type of post-operative patellar subluxation or re-dislocation. However, two of them reported a distinct trauma, which caused a single re-dislocation (grade 1). The other cases were of non-traumatic nature and rather rated as subluxations by the patients (grade 0). Only two of them reported frequently occurring patellar subluxations over the past few years (grade 1). Further surgery was performed in four cases [proximal tibia fracture ($n=1$, grade 2); medial meniscus tear ($n=2$, grade 2); re-Elmslie procedure + Campbell's procedure (retinacular fascioplasty; $n=1$, grade 3)]. The phone survey of an additional nine patients revealed the following: three patellar re-dislocations, one of which was trauma related (grade 1), and two frequently occurring subluxations (grade 1). As a consequence, one re-Elmslie procedure (grade 3), two knee arthroscopies (meniscus tears, grade 2) and three total knee arthroplasties (one unilateral and one bilateral case, grade 2) were reported. To summarise, nine cases (23.1 %) of patellar re-dislocations, four of which were rated as frequent subluxations (10.3 %), were observed.

Discussion

Surgery performed to address recurrent patellar dislocation may alter the original joint kinematics due to modified and rerouted

Table 3 Clinical outcome of case group

Outcome score	Case group
KSS (all cases)	
Knee score	89.9±12.0
Function score	94.8±10.0
KSS (re-dislocation)	
Yes	82.5±17.0
No	91.8±10.0
<i>P</i> , between groups	1.000
KOOS (all cases)	
Total	78.7±18.5
Symptoms/stiffness	79.8±15.7
Pain	80.4±20.3
Function/daily living	80.7±19.7
Function/sports and recreational activities	63.8±26.5
Quality of life	71.9±26.2
KOOS (re-dislocation)	
Yes	72.0±27.4
No	80.4±15.9
<i>P</i> , between groups	0.688

Data are expressed as mean ± standard deviation

knee extensor direction. According to a recent meta-analysis, operative treatment is associated with a higher risk of patellofemoral osteoarthritis [16]. The authors concluded that a delay of surgical intervention, allowing recurrent dislocations to cause further chondral damage, might be responsible for the high risk of osteoarthritis. However, other studies have pointed out that surgical interventions change intra-articular load distribution. A cadaveric study investigating the effects of tibial tuberosity medialisation found a significant increase of patellofemoral contact pressure and increased pressure in the medial tibiofemoral joint compartment when overmedialisation of the tuberosity was undertaken [17]. Another laboratory study revealed relative external rotation and lateral shift of the tibia after tuberosity medialisation [18]. Those altered kinematics of the joint were found to negatively influence the applied correction, leading to potential implications for joint pressure distribution. Furthermore, a recent study demonstrated a 35 % increase of medial contact pressure at 80° of flexion [19]. However, the long-term effects of tuberosity medialisation on potential development of osteoarthritis *in vivo* are according to our current knowledge still unknown. We therefore sought to radiologically determine the rate of tibiofemoral and patellofemoral osteoarthritis up to 30 years after the index procedure.

We observed a relatively high rate of severer signs of osteoarthritis (grades 3–4, 23 %), which however was not significantly different compared to the matched cohort. The only comparable study found in the literature reported 42 % of *definitive* osteoarthritic changes (> grade 2) after a mean

follow-up of 13.4 years [27]. Considering our cases with grade 2 osteoarthritis or worse, our results are slightly inferior to other studies, showing 50 % tibiofemoral and 47 % patellofemoral osteoarthritis, respectively [27]. However, our results are reported after a much longer mean follow-up of 20.9 years compared to 13.4 years. We found another report, which evaluated osteoarthritic changes in the long term after medial patellofemoral ligament (MPFL) reconstruction [28]. This study demonstrated a lower rate of osteoarthritis after this procedure, showing 12 % of patellofemoral osteoarthritis grade 2 and 8 % of tibiofemoral osteoarthritis grade 2 after a mean of 11.9 years post-operatively. The authors investigating patellofemoral osteoarthritis ten to 21 years after Goldthwait and Krogus procedures found full-thickness articular cartilage defects in up to 78 % of all magnetic resonance imaging scans obtained [15]. Furthermore, they observed 14 % of severe osteoarthritis (grade IV) after Goldthwait and 19 % after Krogus procedures, respectively. They concluded that surgical patellar stabilisation was not able to prevent the development of osteoarthritis. We agree with other authors that a delay of surgical restoration may cause disabling osteoarthritis later, as it was observed in our cases [16]. We found a positive correlation between the age of the patient at the time of the Elmslie-Trillat procedure and tibiofemoral but not patellofemoral osteoarthritis. Similar to other reports, the average age at operation in our long-term series was relatively high (30.1 years), owing to former treatment algorithms focusing on longer conservative treatment [14]. We currently perform the Elmslie-Trillat procedure, if indicated, after physeal closure still in the teen years. Our severer osteoarthritis cases may therefore be attributed to either the relatively high age at the time of operation, the procedure with its altered kinematics or idiopathic, maybe genetically determined reasons. Additionally, there seems to be no difference between the appearance of tibiofemoral and patellofemoral osteoarthritis in our cohort, because the distribution of osteoarthritis was relatively similar for both joint compartments (Fig. 2).

Our long-term follow-up showed respectable results in terms of function and pain reduction, with both outcome scores indicating relatively high patient satisfaction despite the obvious evidence of osteoarthritis. The KSS revealed excellent long-term results equalling those of a ten year follow-up [12]. The KOOS demonstrated good results overall and for all subcategories except “sports”, which proved to be slightly inferior on average. Our clinical results were actually better than those of the only comparable long-term evaluation published, which demonstrated a functional decline with time [11]. The authors furthermore reported 64 % of good and excellent results after more than ten years post-operatively [27]. Despite the good results monitored by our applied outcome scores, we observed several cases of re-dislocations with a total of four patients (10 %) reporting recurrent dislocations. Nevertheless, radiographic scores of all re-dislocated cases

were not significantly different from those of the “stable” ones. However, subluxations or re-dislocations may have been a major cause for a restricted ability to perform sports and recreational activities.

This study reports the longest follow-up series evaluating radiographic results after Elmslie-Trillat procedures to date. Nevertheless, there are some shortcomings: First, the case cohort is somewhat limited in size, but given the fact that many procedures were carried out up to three decades ago, we still believe the response rate to be satisfactory. Second, two patients of the phone survey group had undergone implantation of knee arthroplasties while none were yet necessary in our examined case group, indicating a possible bias due to a loss to follow-up. Third, although women are known to be at the highest risk of recurrent patellar dislocation and represent the vast majority (70–90 %) of such cases, all but one patient in our case cohort were of female gender [2, 5]. This, again, suggests that our results may have been biased due to a loss to follow-up of male patients.

Our results show that the Elmslie-Trillat procedure was associated with several cases of advanced tibiofemoral and patellofemoral osteoarthritis in the long term, especially if the procedure was performed late. However, with the given methods and size of this case–control study, these results were not significantly different compared to healthy controls without any history of patellar dislocation. Clinical long-term results were still good to excellent in the majority of patients despite some observed cases of re-dislocations and decreased ability to perform sports.

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Conflict of interest The authors declare that they have no conflict of interest.

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