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Isolated trochleoplasty for recurrent patellar dislocation has lower outcome and higher residual instability compared with combined MPFL and trochleoplasty: a systematic review

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Abstract

Purpose To identify the efficacy of isolated trochleoplasty (TP) as an independent treatment for severe trochlear dysplasia compared with TP combined with medial patellofemoral ligament (MPFL) reconstruction.

Methods Search of current literature using terms (trochleoplasty and medial patellofemoral ligament reconstruction) in the electronic search engines PubMed and Embase, and Medline databases was performed on February 25, 2018, and it yielded 515 abstracts for review. At the end of the search, six articles met specific inclusion criteria and were included in this review. Means were calculated for population size, age and follow-up time. The Kujala score was analyzed as the primary clinical outcome parameter in the meta-analysis. Pooled estimates were calculated for postoperative complications.

Results Six studies with a total of 192 knees (168 patients) were included in this analysis. The isolated TP group comprised of 3 articles with a total of 111 knees, and the TP combined with MPFL group comprised of 3 articles with a total of 81 knees. At the final follow-up, the preoperative Kujala score increased significantly by 21.39 (95% CI 18.94, 23.84; $P < 0.00001$) points in the isolated TP group and by 24.91 (95% CI 15.47, 34.36; $P < 0.00001$) points in the TP combined with MPFL group. The rates of subjective patellar instability including subluxation and anterior knee pain were 1.03% and8.45% respectively. Meanwhile, the rate of objective patellar redislocation was 2.06% in isolated TP group and 0% in TP combined with MFPL group. A total of 8.24% returned to the operating room for additional procedures in the isolated TP group and 7.04% in the TP combined with MPFL group.

Conclusion Trochleoplasty is a useful and reliable surgical technique to improve patellofemoral instability in patients with a dysplastic trochlea. However, it as isolated treatment for patients has lower outcome and higher residual instability compared with combined MPFL and trochleoplasty.

Keywords Trochleoplasty · Medial patellofemoral ligament reconstruction · Patellar dislocation · Trochlear dysplasia

Introduction

The function of the patellofemoral joint is normally maintained by a complex interaction between soft tissues and bony structures. In normal knees, these structures act in harmony to maintain patellofemoral stability. Among these anatomical factors, trochlear dysplasia is a condition in which the femoral trochlea has an abnormal shape and loses its anatomical function [32]. The dysplastic trochlear groove has been recognized as the most important static stabilizer in lateral patellar dislocation [30]. In particular, type B and D trochlear dysplasia, according to the Dejour classification, can cause significant kinematic changes with reduced stability [14]. Multiple techniques and procedures have been described for the management of severe trochlear dysplasia [21, 23]. Trochleoplasty (TP) aims to change the shape of the trochlea to stabilize the patella. The purpose of this procedure is to adjust the abnormal shape of the opposing patella and improve patellofemoral congruency [6]. To address the pathological changes associated with patellar instability, TP is frequently recommended and several authors have highlighted their clinical outcomes.

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Meanwhile, many studies reported other interventions such as medial patellofemoral ligament (MPFL), a part of the medial parapatellar structures, which as the main restraining force to lateral displacement of the patella has been emphasized [5, 9]. In a biomechanical study, Senavongse et al. have reported abnormal trochlear geometry reduced the lateral stability by 70% at 30° flexion, and in full extension the MPFL is more important compared to the trochlea for overall patella stability [26]. Thus, the question arises, performing a trochleoplasty as a single procedure to stabilize the patella might not be sufficient, as it does not address the soft tissue abnormality and stabilize the patella in full extension.

In addition, available literature demonstrates that both TP and MPFL reconstructions are able to obtain good clinical outcomes [3]. Therefore, there is no consensus on a standardized management of patellar instability. Whether an isolated TP reconstruction can be considered as an adequate operative procedure for patients, with its advantages of invasiveness and less technical demands, needs to be assessed in regard of its clinical outcome of patients suffering from patellofemoral joint instability after receiving treatment.

To our knowledge, there is currently no published systematic review that evaluates both subjective and clinical outcomes after true isolated TP reconstruction for the treatment of recurrent patellar instability. The single effect of the TP remains unexplained and is questioned to be sufficient for stabilizing a recurrent dislocating patella. Therefore, we hypothesized a combined correction of the femoral trochlea and reconstruction of the MPFL appears to be more reasonable for improving knee function and reliably prevents redislocations. The purpose of this review was to summarize the existing knowledge of the treatment of patellar instability by analyzing currently available data, such as clinical outcome evaluation and complication rates.

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed when conducting and reporting this review and meta-analysis [13]. The search algorithm according to the PRISMA guidelines is shown in Fig. 1.

Literature search

A systematic review of literature was conducted using databases including Medline, PubMed, Cochrane Collaboration of Systematic Reviews and Embase. Search terms utilized included "patellar dislocation", "trochlear dysplasia", "trochleoplasty", and "trochleoplasties" in databases. Two independent authors conducted the search separately and the search was performed on February 25, 2018. The inclusion

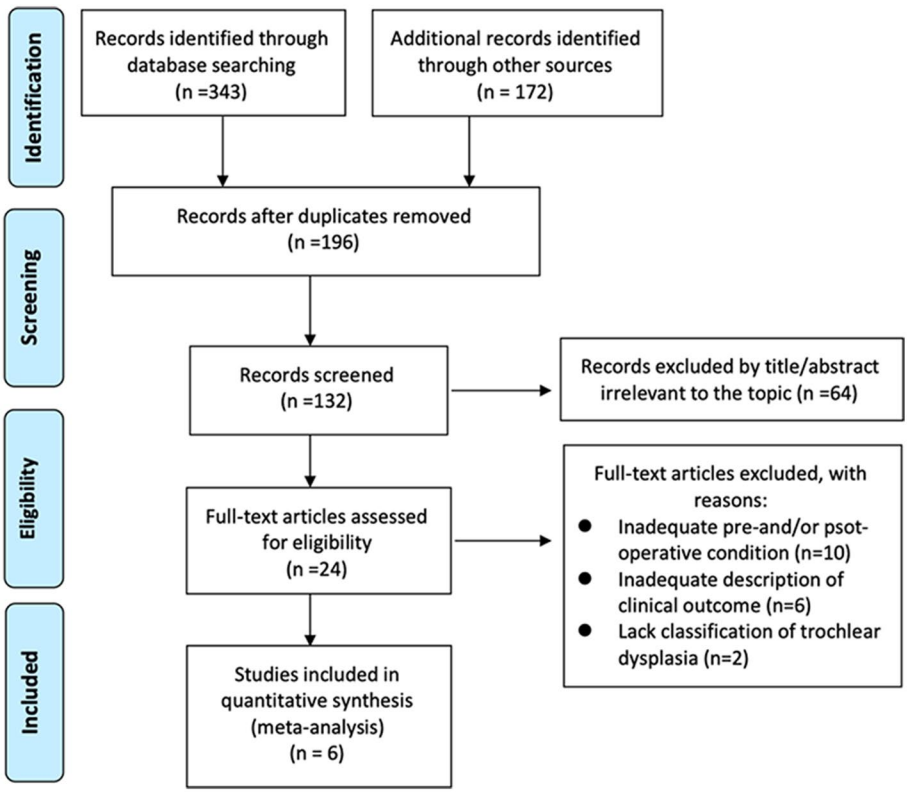

Fig. 1 Flowchart (PRISMA chart) of this systematic review

and exclusion criteria described in Fig. 1 were applied to 515 full-text articles. References listed in recent reviews were also examined to determine the potential for inclusion.

Inclusion criteria

1. Studies including patients with recurrent (≥ 2) episodes of lateral patellar dislocations.
2. Articles must report patients with adequate description of severity of trochlear dysplasia (according to the Dejour classification system).
3. Articles must report a result of all patients received isolated TP reconstruction or simultaneously TP and MPFL reconstruction procedures for chronic/recurrent patellar instability.
4. Studies reporting preoperative constitutions and post-operative clinical outcomes after operative treatment for patellar instability and statistics can be recalculated.

Exclusion criteria

1. Level V evidence, review articles, technical notes, current concept articles, experimental/laboratory studies, case reports and written in languages other than English.
2. Studies with a reported population size < 10 patients.
3. Articles evaluating TP reconstruction with concomitant other main operative procedures (patellar realignment, tibial tubercle osteotomy, long bone osteotomy and so on).
4. Studies that did not report both preoperative constitutions and post-operative clinical outcomes after operation.

Quality assessment

To assess the quality of those studies, we used the Methodological Index for Non-Randomized Studies (MINORS), which assesses the methodology with the use of ten criteria and gives a total score, ranging from 0 to 16 points [27]. Studies were given a score out of 16 because all selected studies were non-comparative. The level of evidence assesses research design quality. Levels of evidence for each study can be seen in Table 1. Each study was scored by three reviewers independently.

Data extraction

The inclusion and exclusion criteria described in Fig. 1 were applied to six full-text articles. All identified articles were reviewed, and abstracts were screened for eligibility according to inclusion and exclusion criteria and decisions were reached by consensus. In addition, references from the included articles were also reviewed. The population size was harvested from each study, as well as means/medians and ranges for population age and follow-up time. Initial screening confirmed that preoperative, postoperative Kujala score, patellar redislocation/subluxation rates and other complications were the most commonly reported.

Statistical analysis

Continuous variables are reported by mean and standard deviation, if available. Non-continuous data such as complications are described by frequencies and proportions. Means were calculated for population size, age, follow-up time, and postoperative Kujala scores. Means were calculated using all available data. If the data were not provided by authors, value was calculated using the number of occurrences of an event of interest divided by knees (such as redislocation, recurrent instability, positive apprehension signs, and reoperations) in the population. The heterogeneity of those studies was assessed by recording the methodological variations and differences in the statistical evaluation using I^2 and chi-squared tests. Postoperative Kujala scores and risk of reoperation were analyzed using meta-analysis (weighted for

Table 1 Critical appraisal of selected studies using MINORS criteria (0, not reported; 1, reported but inadequate; 2, reported and adequate)

	Criteria	Camathias et al. [7]	Donell et al. [10]	Fucentese et al. [11]	Banke et al. [2]	Blond et al. [4]	Nelitzs et al. [17]
1	A clearly stated aim	2	2	2	2	0	1
2	Inclusion of consecutive patients	1	2	2	2	1	2
3	Prospective collection of data	0	1	0	1	2	2
4	Endpoints appropriate to the aim of study	2	2	1	2	1	2
5	Unbiased assessment of the study endpoint	0	2	2	2	2	1
6	Follow-up period appropriate to the aim of the study	1	1	1	2	1	0
7	Loss to follow-up < 5%	1	1	0	0	1	1
8	Prospective calculation of the study size	0	0	1	1	1	1
	Total (out of 16)	7	11	9	12	9	10

individual study size). Individual study means and pooled estimates of postoperative Kujala scores for each individual studies were summarized in a forest plot. Since all studies reported on only one of the treatment groups of interest, namely TP or TP combined with MPFL group, no direct comparison could be performed using the observed data. A random or fixed effects meta-analysis, therefore, was calculated for both groups separately, analyzing the increase in Kujala score. Continuous data were assessed using mean difference with corresponding 95% confidence intervals (CI). A P value < 0.05 was regarded as statistically significant. All statistical analyses were conducted by one author using Review Manager (RevMan version 5.3. Copenhagen: The Nordic Cochrane Centre).

Results

Six studies with a total of 192 knees (168 patients) met the inclusion criteria and were included in this analysis. The data extracted from all the included studies are presented in Table 2. The isolated TP group comprised of 3 articles with a total of 111 knees (97 patients) and a mean follow-up of 39 months. Among them, 94 knees underwent the "modified Bereiter and Gautier" procedure and 17 knees underwent the "Dejour" procedure. All of these studies performed the TP as an isolated procedure. In comparison, the TP combined with MPFL group comprised of 3 articles with a total of 81 knees (71 patients) and a mean follow-up of 29.8 months. Two studies with 44 knees performed "modified Bereiter and Gautier" and one study with 37 knees performed "Arthroscopic deepening TP". In all three studies, the TP procedure was accompanied with a simultaneous MPFL reconstruction.

Outcome of Kujala score

The preoperative Kujala scores are shown in Table 3. To the final follow-up, the preoperative Kujala score increased significantly by 21.39 (95% CI 18.94, 23.84; $P < 0.00001$) points in the isolated TP group and by 24.91 (95% CI 15.47, 34.36; $P < 0.00001$) points in the TP combined with MPFL group (Fig. 2a, b). It is interesting to note that the

Table 2 Demographics of included studies

Study (author)	Year	Patient (male/female)	No. of knee	Mean age (year)	Trochlear dysplasia (B/C/D)	Follow-up (months)
Isolated TP group						
Camathias et al. [7]	2016	44 (14/30)	50	15.6 ± 2.0	27/17/6	33
Donell et al. [10]	2006	15 (3/12)	17	25 (15–47)	0/0/17	36
Fucentese et al. [11]	2011	38 (10/28)	44	18 (14–40)	15/9/11	48
Total		97 (27/70)	111		42/26/34	39
TP + MPFL group						
Banke et al. [2]	2014	17 (6/11)	18	22.2 ± 4.9	4/11/3	30.5
Blond et al. [4]	2014	31 (10/21)	37	19 (12–39)	10/11/16	29
Nelitz et al. [17]	2014	23 (14/9)	26	19.2 (15.4–23.6)	0/0/26	30
Total		71 (30/41)	81		14/22/45	29.8

Data are shown as the mean ± SD (range)

Table 3 Preoperative and final Kujala scores for trochleoplasty and combined MPFL group

Intervention	Study	Trochleoplasty technique	Preoperative Kujala score mean (SD)	Final Kujala score mean (SD)
Isolated TP group				
	Camathias et al	Modified Bereiter and Gautier	71 (7.8)	92 (5.7)
	Donell et al	Modified Dejour	48 (15.85)	74.59 (16.82)
	Fucentese et al	Bereiter and Gautier	68 (20)	90 (14.2)
TP + MPFL group				
	Banke et al	Modified Bereiter	51.1 (22.9)	87.9 (12.9)
	Blond et al	Arthroscopic deepening trochleoplasty	64.4 (15.1)	88.8 (13.7)
	Nelitz et al	Modified Bereiter and Gautier	79 (16.3)	96 (7.6)

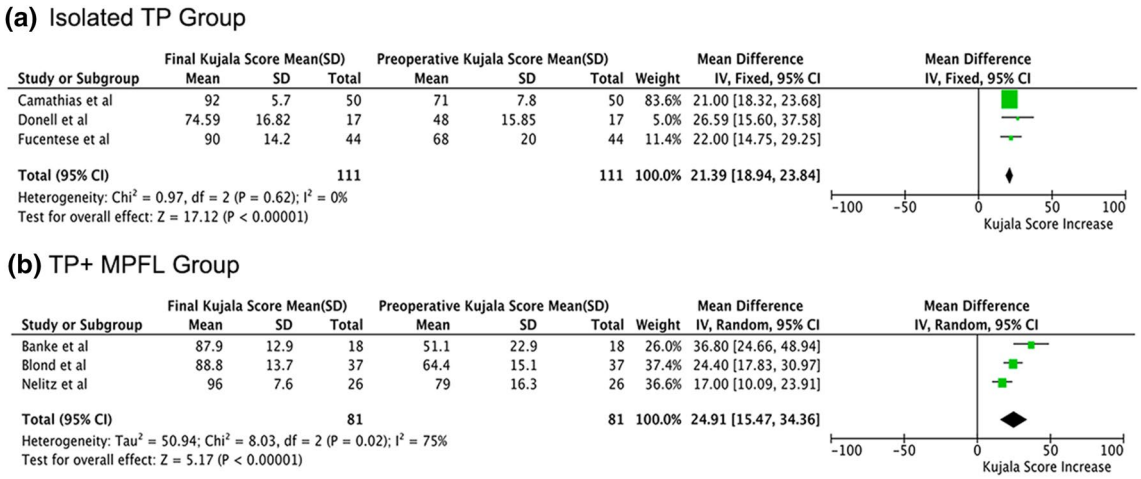

Fig. 2 Forest plots of the preoperative to final Kujala score increase of patients with trochlear dysplasia in the isolated TP group (**a**) and TP combined with MPFL group (**b**)

equivalence of postoperative improvements in patients undergoing isolated trochleoplasty for recurrent patellar dislocation has lower outcome.

Complications

Broad classifications of complication included subjective patella instability and objective patella redislocation. A pooled comparison of complications can be seen in Table 4. Subjective patella instability included subluxation and pain. There is one patient who suffered complex regional pain in the isolated TP group, and four patients in the TP combined with MPFL group. According to Blond et al., to make combined arthroscopic deepening TP and MPFL reconstruction, three patients experienced pronounced postoperative anterior knee pain at flexion [4]. Finally, we set patellar subluxation and anterior knee pain as positive apprehension signs which mean failure to stabilization. The rate of subjective patellar instability was 1/97, 1.03% vs 6/71, 8.45% when compared with isolated TP group and TP combined with MPFL group. It may be evident that combining procedures always mean combining reasons for subjective patellar instability; thus, the more the procedures are combined, the more the complications that may occur.

On the other hand, there is one patient redislocated postoperatively and one patient experienced a new recurrent

Table 4 Detailed complications and reoperation after TP or TP combined with MPFL reconstruction

Study	Level Evidence	Complication	Reoperation
Isolated TP group			
Camathias et al	IV	One patella redislocated postoperatively after 38 months	Four patients underwent arthroscopic debridement to release the adhesions
Donell et al	IV	Six knees showed marked crepitus which troubled the patients	One patient received a chondroplasty surgery
Fucentese et al	III	One transient postoperative femoral neuroplasty after peripheral anesthesia, one wound-healing problem and one complex regional pain syndrome	One patient experienced a new recurrent atraumatic dislocation. Two patients with residual instability underwent a further stabilization surgery
TP + MPFL group			
Banke et al	IV	One knee with painful medial subluxation of the patella and inability bent the knee > 20°5 days after surgery	Two knees with persistent reduced range of movement underwent early arthroscopic arthrosis successfully
Blond et al	IV	Two patients developed symptomatic subluxations 28 months postoperatively and J-sign relapsed. Three patients suffered postoperative anterior knee pain	Three patients received lateral release surgery to alleviate pain
Nelitz et al	III	Patellofemoral crepitus was present in 3 of 26 knees but without pain	No

traumatic dislocation in the isolated TP group (2/97, 2.06%). The TP combined with MPFL group showed significantly lower rates (0%) for the patellar redislocation, because no case was reported.

Meanwhile, many factors associated with revision surgery among all the reports. This study classified revision rate as a separate entity when the overall evaluation. The isolated TP group reported four patients who underwent arthroscopic debridement to release the adhesions, one patient experienced a new recurrent traumatic dislocation, and two patients with residual instability underwent a further surgery. Differently, TP combined with MPFL group reported that two knees with persistent reduced range of movement underwent early arthroscopic arthrosis successfully and three patients received lateral release surgery to alleviate pain. A total of eight patients (8/97, 8.24%) returned to the operating room for additional procedures in the isolated TP group and five patients (5/71, 7.04%) in the TP combined with MPFL group.

Discussion

Even when acknowledging these limitations, this is the first study intended to determine clinical outcomes after treating with isolated TP procedures for patients with patellar instability. Recently, surgical reconstruction of TP has gained much popularity in the treatment of patellar dislocations, particularly in settling recurrent dislocations and/or chronic instability [16]. While previous literature has addressed the outcomes after treating with TP, methodologies of various studies have differed greatly. Many studies included patients who underwent additional surgical procedures (e.g., tibial osteotomy or MPFL reconstruction) within their studies [22, 28, 29]; therefore, outcome as a stand-alone treatment is rarely evaluated. Longo et al. evaluated three major types of trochleoplasty associated with significantly improved stability, function and Kujala scores and a relatively low rate of osteoarthritis and pain [17]. They pointed that Bereiter U-shaped deepening trochleoplasty was the most commonly used technique for the treatment of trochlear dysplasia and it has the lowest rate of recurrence and post-operative ROM deficiency. Nevertheless, the limitation of this study is that TP was never performed alone, so is difficult to evaluate exactly the effect of this procedure. In addition, the interpretation of the clinical results is further complicated by the great individual variability in terms of combinations of and differences in risk factors that make it difficult to accurately isolate their roles to patellar instability. In contrast with other previous studies, ours only compared patients treated with the TP, as the primary and stand-alone procedure without additional interventions. Striving to perform a review, we faced with major limitations resulting from the available literature on patellar instability. Many published studies were excluded from this analysis due to inadequate preoperative analysis of anatomic risk factors, heterogeneity of study groups, small sample sizes, and varying TP surgical procedures [24]. To minimize those confounding factors, a strict selection process, including only studies with adequate description of severity of trochlear dysplasia and similar reporting of post-operative clinical outcomes, was used.

Typically, recurrent patellar dislocation is associated with multiple anatomic predisposing factors in the majority of patients. Fitzpatrick et al. pointed out that the contribution of four key factors (sulcus angle, patella alta, TT–TG distance, and femoral anteversion) has the greatest impact on the majority of patients [10]. The presence of a trochlear bump, as seen particularly in Dejour type D, was the most important factor in adversely affecting patellofemoral kinematics and increasing contact pressures. In our study, we noticed that TP + MPFL group has more type D trochlear dysplasia compared with the isolated TP group (45 vs 34 knees, Table 2). It might be reasonable to consider that there was only little difference seen between the Kujala scores in the two groups because most patients with a type D dysplasia had the TP + MPFL procedure.

It is interesting to note that most authors agree that TP is a successful treatment for patellar dislocation in the setting of trochlea dysplasia, regardless of the type of technique [2, 11, 15]. Despite this, it is difficult to evaluate the efficacy of TP as a uniform procedure due to different surgical techniques. In our study, the main type of isolated TP surgery technique was the modified Bereiter and Gautier [7, 12]. Longo UG et al. have done a systematic review to compare the clinical outcomes of patients treated with different TP procedures [18]. They have pointed out that none of the TP surgical techniques analyzed highlighted a real superiority.

Beaufils et al analyzed and summarized the incidence of recurrent dislocations after trochlear osteotomies and reported a maximum of 10% (2 in 20 patients) remained suffering from objective patellar instability [3]. Our results showed the pooled estimate of all postoperative recurrent patellar redislocations was 2.06% in the isolated TP group. This rationale is possibly supported by deepening TP procedures performed by Camathias et al. [7]. Their patients were clearly younger (mean age, 15.6 years) and isolated TP needs to compensate for patella alta by advancing the TP more proximal by lateral elevation and proximalization. On the other hand, there was lower postoperative redislocation (0%) in TP combined with MFPL group. As assumed by Nelitz et al., a combined MPFL and trochleoplasty does not need to deepen and bend the osteochondral flap to the same extent as that of the isolated trochleoplasty because parts of the overall stabilizing procedure are derived from the MPFL [19]. A biomechanical study by Senavogse et al. pointed out that abnormal trochlear geometry reduced the lateral

stability by 70% at 30° flexion, while relaxation of vastus medialis obliquus caused a 30% reduction [26]. Therefore, regarding the contributory stabilizing bony and soft tissue stabilizers in patellofemoral instability, the trochlea is the most important stabilizer in flexion over 20°–30°, but in the first 0°–20° of flexion, the most important stabilizer is the MPFL. By biomechanical evidence we have currently, maybe scaring of the soft tissue including the MPFL during TP is leading to some kind of stability in extension. This is also the reason why the TP with MPFL group has lower postoperative redislocation.

The current literature remains inconclusive regarding any link between trochleoplasty and patellofemoral osteoarthritis. After a mean of 8 years, von Knoch et al. noted the presence of patellofemoral osteoarthritis in 30% of their patients treated with a Bereiter trochleoplasty procedure [31]. Less cartilage manipulation seems to cause less osteoarthritis in the long term. Our results showed that the isolated TP group has higher revision rate (8.24% vs 7.04%) when compared with TP combined with MPFL group. The modified isolated trochleoplasty by Camathias et al. used an elevation and proximalization of the lateral femoral condyle; thus, pressure elevation to the lateral patellofemoral joint may occur, but less stability in full extension as well, because the MPFL is still insufficient. Treating the lack of MPFL by extraanatomic proximalization may cause early patellofemoral arthritis. On the other hand, it is important to note that the studies in isolated TP group in which patients have shorter follow-up time and the dysplastic trochlea itself represents a risk factor for degenerative changes need long-time observation.

Finally, limitations of this article should be interpreted. Many studies of potential interest could not be included in this analysis. The main reasons were not-described severity of trochlear dysplasia, the surgery often combined other interventions, inadequate reporting of pre-and/or post-operative conditions and different clinical outcome measures [8, 20, 25]. To minimize those confounding factors, a strict selection process should be used. Ideally, all of the studies should report the same standardized surgical procedure and scoring systems, to make analysis more homogenous. Different from previous research, the patients included in the study by Camathias et al. were clearly younger (mean age, 15.6 years) and had a high capacity to cope [7]. In consequence, the trochleoplasty fulfilled the goal of stability in this high-demanding population, as shown by increased satisfaction rates. This fact could positively influence outcomes. Given these facts, they, therefore, believe that TP serves best in young patients with only a few dislocations. On the other hand, use of Kujala score as primary outcome measure has been the most widely used patient-reported outcome measure for the evaluation of patellofemoral disorders. However, the pre-operative more focused on the evaluation of pain than instability. With this in mind, the implementation of more specifically designed outcome measure should be recommended for future studies, and it will be interesting to observe whether these reveal any differences in results. Meanwhile, evidence level of most studies we analyzed were Level IV, consigning our systematic review to the same limitations inherent within this level of evidence. More long-term prospective study and higher level of evidence studies are needed to assess isolated TP procedures. Even when recognizing these limitations, this is the first study that allows a quantitative comparison between isolated TP procedure and TP combined with MPFL reconstruction for patients with severe trochlear dysplasia, and as such, is a relevant addition to the literature.

Conclusion

Trochleoplasty is a useful and reliable surgical technique to improve patellofemoral instability in patients with a dysplastic trochlea. However, isolated trochleoplasty has higher rates of persistent instability and thus lower outcome score. It as isolated treatment for patients needs implementation of more objective criteria or establishment of more uniform criteria for selecting patients.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

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