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UP-TO DATE REVIEW AND CASE REPORT • KNEE- PATELLA

Distal alignment procedures for patellofemoral instability: comprehensive review of the literature

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Abstract

Patellofemoral disorders are a common cause of complaint in adolescent patients. Several distal realignment procedures performed in isolation or combination with proximal alignment have been described. To clarify the role of distal alignment for patellofemoral instability, a systematic review of the literature was conducted. Two independent reviewers accessed the following databases: PubMed, Medline, CINAHL, Cochrane, EMBASE and Google Scholar. A total of 1478 patients with a mean age of 22.78 years were included. The mean follow-up was 86.53 months. The average Kujala score improved from 57.66 to 82.73. The average Lysholm score improved from 63.25 to 87.87, and the average Tegner score from 3 to 4.16. VAS score improved from an average 8 to 2.56. We account a total of 46 major complications, 45 minor complications and 95 recurrences. The risk of a recurrence is 6.42%. A total of 122 additional surgeries were performed during the follow-up. This systematic review of literature suggests the importance to identify the pathological background that predisposes patients for developing patellofemoral instability and its implications for the decision-making process. The optimal treatment for patellofemoral instability should be individualized to address the specific anatomical abnormalities that contribute to patellofemoral dislocations. Distal alignments are a feasible solution to restore correct patellar biomechanics and tracking, leading to an improvement of patients' quality of life.

Keywords Patellofemoral instability · Bony procedure · Tibial tubercle transfer · Dislocations · Failure

Introduction

Patellofemoral disorders represent a common cause for complaint in adolescent patients [1]. About 3% of knee-related complaints involve patellar dislocations [2]. Due to the multifactorial aetiology, it can be a challenge for an orthopaedic surgeon to correctly identify and treat these pathologies [3]. Lower limb rotational deformities represent a common pathological substrate that predisposes a patient for patellofemoral instability [4]. TT-TG is a common measurement to evaluate rotational deformities [5]. A TT-TG over 22 cm creates a tendency for lateral displacement of the patella, sensations of instability and anterior knee pain, thus representing an indication to a distal alignment [6]. Several distal realignment procedures performed in isolation or combination have been described [7]. Distal alignments, such as tibial tubercle transfer [8], Elmslie–Trillat [9], Roux–Goldthwait [10], Fulkerson [11] and Maquet [12], have the purpose to restore the physiological joint alignment, preventing the lateral displacement of patella [13]. Despite the reported success of these procedures, several complications have been reported, ranching from pain to pseudarthrosis [7]. To this day, there is still a significant lack of information about clinical outcomes and complications concerning distal alignment [14, 15]. A systematic review of the literature was performed, with the purpose to update current evidence and clarify the role of the distal alignments for patellofemoral instability.

Materials and methods

Literature search

A comprehensive review of literature was performed according to the Preferred Reporting Items for Systematic

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Reviews and Meta-Analyses guidelines (PRISMA) [16]. Two independent reviewers (FM, JE) performed the study in October 2018. The following databases were accessed: PubMed, CINAHL, Medline, Cochrane, Google Scholar and EMBASE. The following keywords were used for the search in combination: *patellofemoral, instability, dislocation, re-dislocation, recurrence, failure, distal alignment, bony procedures, mal-alignment, osteotomy, tibial tubercle transfer, Elmslie–Trillat, Roux–Goldthwait, Fulkerson, Maquet.*

Data extraction and eligibility criteria

Data extraction was performed by two independent authors (FM, JE). Titles resulting from the literature search were screened, and if of interest, the abstracts were read. If the abstract reported relevant information concerning the outcomes of interest, the full-text versions were accessed. Additionally, the bibliographies of these articles were screened. Studies published in English, German, French, Spanish or Italian languages were considered for inclusion. According to the Oxford Centre for Evidence-Based Medicine, studies with levels of evidence I to IV were included [17]. Review, techniques, comments, letters, editorials, protocols and guidelines were excluded, along with biomechanical, in vitro, animal and cadaveric studies. Only studies which treated distal alignments for the patellofemoral instability were included. We considered articles that reported quantitative data under the outcomes of interest. Missing data pertinent to these parameters warranted exclusion from this systematic review. Disagreements between the authors were debated and mutually agreed upon.

Outcome of interest

Two investigators (FM, JE) extracted the following data independently: demographic, type of surgery, pre- and post-operative measures, complications and further dislocations, and revisions surgery. Regarding the pre- and post-operative measurements, we referred to clinical scores (Kujala Anterior Knee Pain Scale [18], Lysholm Knee Scoring Scale [19], Tegner Activity Scale [20], visual analogic scale). Post-operative complications were recorded and divided into major (nerve palsy, non-union, compartment syndrome, footdrop, patella alta or baja, break in a bone splint or tear in the tuberositas tibiae, pseudarthrosis, fractures, abscess, knee stiffness, arthrofibrosis) and minor complications (hemarthrosis, swelling, haematoma, screw irritation, marginal skin necrosis, wound infection, reduced rom, neurinoma, pain and irritation).

Methodological quality assessment

The Coleman Methodology Score (CMS) was performed to evaluate the methodological quality assessment. The CMS evaluated the enrolled studies regarding several criteria: number of samples, follow-up, type of study, description of diagnosis, surgical technique and post-operative rehabilitation, outcome criteria, assessing method, selection process. The final score is defined as poor (< 50 points), fair (50–69 points), good (70–84 points) or excellent (85–100 points).

Statistical analysis

The statistical analysis was performed with Microsoft Excel 2017. For continuous data, the arithmetic mean and the standard deviation were considered. To evaluate the statistical significance of continuous data, a *t* test was performed. A value of $p < 0.05$ was considered statistically significant.

Results

Search result

The literature search and cross-referencing resulted in a total of 1996 articles. Of these, 483 were rejected for being duplicates. Another 1410 were rejected because they did not focus on the topic of interest, did not report any quantitative data or did not match the eligibility criteria. This left 103 publications for review. After reading the remaining full-text articles, 56 further articles were excluded because of insufficient details and/or being combined with other surgeries which were not of interest. Finally, 47 articles were considered for the analysis. The flow chart of literature search is shown in Fig. 1.

Methodological quality assessment

The CMS resulted in 52.57 ± 4.34 points, attesting to this work an acceptable methodological quality assessment. The strong points of this analysis are represented by the long follow-up and the number of included patients. Moreover, most of the studies performed only one type of surgery, with related surgical technique explanation and well-described post-operative protocols. The most important limitation of the CMS is represented by the poor level of evidence of the included studies, since 93.6% of the included studies are retrospective analyses. The CMS score for each study is shown in Table 1.

Demographic data

A total of 1478 patients were included, undergoing a mean follow-up of 86.53 ± 73.99 months. The mean age was

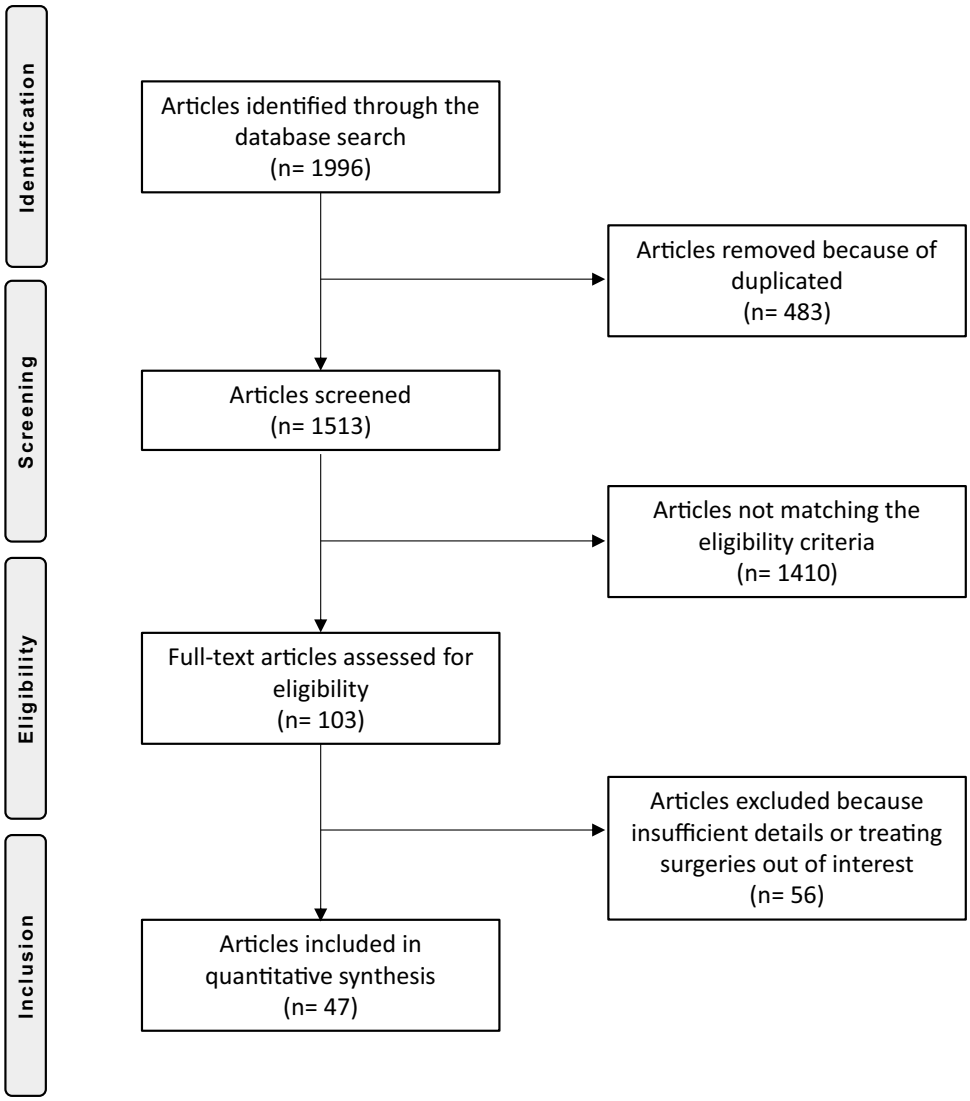

Fig. 1 PRISMA flow chart of the literature search

22.78 ± 8.65 years. The demographic data are shown in Table 1.

Outcomes of interest

The average Kujala Anterior Knee Pain Scale improved pre-operatively from 54.91 ± 15.54 to 81.91 ± 8.14 post-operatively ($p < 0.0001$). The average Lysholm Knee Scoring Scale improved from 58.06 ± 9.34 to 85.37 ± 10.58 post-operatively ($p < 0.0001$), and the average Tegner Activity Scale from 3.61 ± 1.31 to 4.44 ± 1.06 ($p = 0.0435$), respectively. The average visual analogic scale improved from 6.10 ± 1.45 to 2.56 ± 1.06 post-operatively ($p = 0.0001$). Among 1478 surgical procedures, a total of 95 (6.42%) re-dislocations were observed. A total of 122 further surgeries were performed during the follow-up, consisting mostly of screw removals ($N = 54$). Major complications occurred rarely. All studies described complications and re-operations. We account for a total of 46 (3.125%) major complications and 45 (3.03%) minor complications. The analysed surgical procedures, related failures, complications and additional surgeries are shown in detail in Table 2.

Discussion

The main findings of this systematic review judge distal alignments to be a feasible and safe solution to treat patellofemoral instability in presence of patho-anatomical predisposing factors. We evidenced low rates of complications, re-dislocations and re-operations during the medium-term follow-up. All the scores of interest reported statistically significant improvement from baseline, increasing the patients' quality of life remarkably.

Table 1 Demographic baseline of the enrolled studies and CMS score

References	Level of evidence	CMS	Knees (*n*)	Mean age	Follow-up (months)
Äärimaa et al. [21]	III	52.5	16	25	51.6
			28	21	
Ahmad et al. [22]	II	48	16	24.8	30
Akgün et al. [11]	III	48	17	25	31.2
Barber et al. [23]	III	54	35	27.7	98
Belmont et al. [24]	III	54	58	28.1	39.6
Benoit et al. [25]	III	50	12	10.3	162
Bettuzzi et al. [26]	III	50	10	10	114.4
Biglieni et al. [27]	III	54	20	13.4	81.6
Carney et al. [28]	IV	48	15	20.5	33.8
Chen et al. [29]	III	51	25	21.5	36.8
Damasena et al. [30]	I	71.25	16	16	60
			17	21	60
Dannawi et al. [31]	III	51	20	29.15	45
Dantas et al. [32]	III	51	24	22	52
Dickschas et al. [33]	IV	54	49	27	42
Dickschas et al. [34]	III	51	32	30.1	37
Endres et al. [35]	III	54	18	28.2	116.4
Fouilleron et al. [36]	IV	48	42	21.1	24
Henderson et al. [37]	III	54	108	25.4	29.2
Joo et al. [38]	IV	47	6	6.1	54.5
Kanamiya et al. [39]	IV	51	25	22	49
Karataglis et al. [40]	III	51	44	31	40
Koëter et al. [41]	II	58	30	23	24
Kraus et al. [42]	III	57	58	8	100.8
Kreuz et al. [43]	III	54	15	15.8	90
Kumar et al. [44]	III	51	18	23	36
Lim et al. [45]	III	44	14	21.3	16.5
Lin et al. [46]	III	50	12	68.5	67
Malecki et al. [47]	III	54	33	18	67.2
Marcacci et al. [48]	III	51	18	21.1	60
Marsh et al. [10]	III	54	30	14.2	74.4
Mayer et al. [49]	IV	54	27	20.4	124.8
Mitani et al. [9]	III	54	31	25.2	156
Nakagawa et al. [50]	III	54	45	18.4	161
Oliva et al. [51]	IV	51	25	13.5	45.6
Paulos et al. [52]	III	47	12	20	48
Price et al. [53]	III	44	5	68.8	29.7
Pritsch et al. [54]	III	57	69	21	74.4
Rantanen et al. [55]	IV	54	35	23	72
Rillmann et al. [56]	III	54	36	278.4	62.8
Rosso et al. [57]	IV	57	78	43.5	67.9
Schneider et al. [58]	III	54	17	16	120
Shen et al. [59]	IV	50	13	25.4	67.3
Sillanpää et al. [60]	III	54	21	20	84
Tjoumakaris et al. [61]	IV	51	41	20.05	46
Tsuda et al. [62]	III	57	62	20	115
Vivod et al. [63]	III	56.25	10	45	270
			8	44	
Wang et al. [64]	IV	57	62	45.7	128.5

Table 2 Surgical procedures and related complications, re-dislocations and further re-operations

Surgical procedure (*n*)	Complications	Re-dislocations	Additional surgeries
Elmslie–Trillat (273)	Superficial wound infections (3), TT screw irritation (2), paraesthesia of the infrapatellar branch of the saphenous nerve (1) Knee stiffness (2), pseudarthrosis (1), deep vein thrombosis (1), fractures (4), abscess (1), footdrop (1), arthrofibrosis (1), patella baja (2)		Screws removal (4), arthroscopic lavage (1), medial plication due to loosening of the medial structures (3), LR (2), TKP (3), revision (1)
Elmslie–Trillat combined with proximal procedure (45)	Marginal skin necrosis (2)	Traumatic dislocations (2)	Patients underwent a medial reefing (3), patients underwent a loose body removal for fragments that had broken off the patella (2); patients underwent chondroplasty (5)
Elmslie–Trillat combined with Albee trochleoplasty (8)	0	1	0
Elmslie–Trillat/Roux–Goldthwait (14)	Superficial skin infection	0	0
Fulkerson (84)	Hemarthrosis (1), compartment syndrome (1), peroneal nerve palsy (1)	0	Revision surgery (1), removing screw (3), surgical revision (1) fibula pseudarthrosis (1)
Fulkerson combined with proximal procure (66)	Non-unions (3), peroneal, nerve palsy (1), compartment syndrome (1), temporary peroneal paresis (1), patella baja (1)	1	Revision surgery with an autogenous bone graft (3), additional lateral release combined with a repair of the medial retinaculum (1), additional intervention (3), shaving (1), medial incision retinaculum (1)
Goldthwait technique combined with lateral release (20)	Post-operative swelling of the joint (5), break in a bone splint or tear in the tuberositas tibiae (9)	Unstable patella with a tendency to subluxation (1)	0
Grammont (58)	Deep vein thrombosis (1)	–	Elmslie–Trillat patellar realignment (2), open arthrolysis (1)
Hauser (35)	Foot drop post-operatively (1), limited range of movement (1)	20	Extensor realignments (1), patellectomies (4), arthroscopic debridement (1)
Osteotomy (184)	Haematoma (1), superficial infections (2), haematoma (10), infection (2), tibial fractures (2), neuroma (1)	4	Additional medial reefing procedure (1), screw removal (35), patellectomy (1), other (1)
Osteotomy combined with lateral release (108)	0	11	0
Roux–Elmslie–Trillat (33)	Fracture (1)	0	0
Roux–Goldthwait (66)	0	Isolated dislocation (4), recurrent dislocation (2), other (4)	Shaving for severe cartilage degeneration and removal of loose bodies (5)
Roux–Goldthwait combined with proximal procedures (68)	Superficial wound infections (2), patellar tendon length greater than 52 mm post-operatively (2), pseudarthrosis of the tibial tubercle osteotomy site (1)	1	Debridement and removal of hardware (1), surgical debridement and repeat fixation (1)
Roux–Goldthwait–Campbell (10)	0	Traumatic dislocation (1)	MPLF reconstruction (1)

Table 2 (continued)

Surgical procedure (*n*)	Complications	Re-dislocations	Additional surgeries
Patellar tendon transfer combined with lateral release and VMO advancement (25)	0	0	Arthroscopic debridement and closed manipulation for a flexion deficit (1), plate removal (1)
Tibial tubercle transfer combined with proximal procedures (183)	Mild wound infection, a tibial fracture through the distal fixation screw site (2), deep venous thrombosis (2), reduced ROM (2), fracture (1), non-union (1), infection (1), non-union (1), pain and irritation (12)	Isolated dislocation (3), instable patella (1)	Revision surgery (2), application of cylinder cast (1), screw removal (16), arthroscopic debridement (1), bone grafting (2), screw removal (1)
Tibial tubercle transfer (237)	Non-union of the osteotomized tibial tubercle (1), non-displaced fracture of the proximal tibia (1), saphenous neuroma that resolved (1), non-union of the osteotomized tibial tubercle (1)	Dislocation (1), occasional subluxations (4), lateral subluxation (1), other (7)	Bone grafting (1), long leg plaster of Paris (1), bone grafting (1)

Despite the numerous studies, there is a lack of consensus regarding the management of patellofemoral instability, and the best treatment methods remain elusive [65, 66]. Due to its multifactorial aetiology, treating patellofemoral instability can represent a challenge [67, 68]. The orthopaedic surgeon should consider all static and dynamic factors that contribute to developing joint instability [69]. Among patients suffering from patellofemoral instability, most show two or more concomitant predisposing patho-anatomical factors that synergistically interact [70–73]. Therefore, it is mandatory to analyse the patient thoroughly, evaluating the impact of each risk factor. Relevant anatomical abnormalities, such as rotational deformities and/or patella alta, show a high morbidity in patients suffering from patellofemoral instability [74, 75], and they required often additional surgeries [66].

Over the past few years, an increased attention concerning the medial patellofemoral ligament (MPFL) has been evidenced [69, 76]. Firstly, the MPFL is the most important dynamic restrain to the lateral displacement of the patella during the first 30° of flexion [77]. Secondly, this ligament is always damaged or ruptured after the first dislocation [78]. Thirdly, the surgical reconstruction is characterized by a high level of patients' satisfaction, and excellent clinical and functional outcomes [79, 80]. Furthermore, being a soft-tissue procedure, the MPFL reconstruction can be performed in skeletally immature patients [81]. These evidences clarify the wide spread of the MPFL reconstruction as treatment for patellar dislocations [82]. However, an isolated MPFL reconstruction must be evaluated with caution [83, 84]. The MPFL rupture is not the cause of the dislocation, but rather the consequence. In selected patients, it becomes rationale to combine the MPFL reconstruction with a distal realignment, in order to restore the correct patellar biomechanics and tracking [73, 85]. A recent biomechanical study by Redler et al. [86] found that in patients suffering from tibial extrarotation or patella alta, an isolated MPFL reconstruction leads to higher rate of failure than when combined with a distal alignment. They additionally stated that is not possible to reconstruct an isometric MPFL in patients with underlying rotational deformities or patella alta [86]. As the purpose of this systematic review, we analysed the outcomes of the distal alignment. According to the result of this study and the current evidence, we found these procedures effective and feasible, since the lead to a considerable improvement of the quality of life. Furthermore, we reported a low rate of complications and recurrences during the medium-term follow-up. All scores of interest improved remarkably, with a statistically significant result.

Important limitations of this study are the low level of evidences of the included studies and the high variability of surgery types. Most of the studies were level III of evidence; therefore, available data must be interpreted with caution.

Further studies should improve the evidences related to these procedures, providing to a randomization or blinding methods of their patients' cohort.

Conclusion

This systematic review of literature suggests the importance of characterizing the pathological background that predisposes patient in developing patellofemoral instability and his implication in the decision-making process. The optimal treatment for patellofemoral instability should be individualized to address the specific anatomical abnormalities that contribute to patellofemoral dislocations. Distal alignments are safe and feasible solution to restore correct patellar biomechanics and tracking, leading to an improvement of the patient's quality of life.

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Compliance with ethical standards

Conflict of interest The authors declare any potential conflict of interest.

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