Original Article

Conservative Versus Surgical Treatment for Primary Patellar Dislocation

A Systematic Review to Guide Risk Stratification

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Summary

Background: Primary patellar dislocation is often the initial manifestation of patellofemoral instability. Its long-term consequences can include recurrent dislocation and permanent dysfunction of the knee joint. There is no consensus on the optimal treatment of primary patellar dislocation in the relevant literature. The main prerequisite for a good long-term result is a realistic assessment of the risk of recurrent dislocation.

Methods: We carried out a systematic literature search in OvidSP (a search engine for full-text databases) and MEDLINE to identify suitable stratification models with respect to the risk of recurrent dislocation.

Results: In the ten studies included in the current analysis, eight risk factors for recurrence after primary patellar dislocation were identified. Six studies revealed a higher risk in younger patients, particularly those under 16 years of age. The sex of the patient had no clear influence. In two studies, bilateral instability was identified as a risk factor. Two anatomical risk factors—a high-riding patella (patella alta) and trochlear dysplasia—were found to have the greatest influence in six studies. In a meta-analysis of five studies, patella alta predisposed to recurrent dislocation with an odds ratio (OR) of 4.259 (95% confidence interval [1.9; 9.188]). Moreover, a pathologically increased tibial tuberosity to trochlear groove (TT-TG) distance and rupture of the medial patellofemoral ligament (MPFL) on the femoral side were associated with higher recurrence rates. Patients with multiple risk factors in combination had a very high risk of recurrence.

Conclusion: The risk of recurrent dislocation after primary patellar dislocation is increased by a number of risk factors, and even more so when multiple such risk factors are present. Published stratification models enable an assessment of the individual risk profile. Patients at low risk can be managed conservatively; surgery should be considered for patients at high risk.

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With 6 events per 100 000 population, patellar dislocation is a common knee injury in Germany (1). Even though a considerable number of reviews comparing surgical and conservative treatment have been published, the optimal treatment for primary patellar dislocation remains the subject of controversy. While sheared-off chondral or osteochondral fragments are either surgically reattached or, if too small, removed, no consensus has so far been reached on the best strategy of treatment in patients with no such concomitant injuries (2–6). Recurrent episodes of patellofemoral instability are associated with a high incidence of cartilage injury (70–86%) (7, 8), considerably limiting the ability of these typically young patients to engage in an active lifestyle (9). Consequently, the aim of any treatment approach should be to prevent redislocation in the long term. The

success of these interventions is largely determined by the initial patient contact.

According to current literature, conservative treatment is associated with comparatively high redislocation rates of up to 66% (4, 5). However, only limited conclusions can be drawn from most of these studies due to the heterogeneity of patient samples, failure to include relevant risk factors, and the use of different surgical techniques for comparison, some of which are obsolete (10). Against the backdrop of outdated dogmas or for lack of evidence-based alternatives, conservative treatment is often initially preferred in first-time patellar dislocation (11, 12). To estimate the risk of redislocation, various predictive risk stratification models are available which can be used to support decision making after careful analysis

The clinical perspective

To date, there is no consensus on the treatment of primary patellar dislocation. Thus, against the backdrop of outdated dogmas, conservative treatment is often chosen as the initial approach. In our view, however, the first patient contact after the primary event is crucial for the success of the treatment of patellofemoral instability. The ultimate goal of this treatment should always be to prevent recurring dislocation. A thorough analysis of potential risk factors is required to be able to estimate the likelihood of redislocation and to plan the further treatment based on these results. Besides patient age, special attention should be paid to anatomic risk factors, such as patella alta, trochlear dysplasia, lower-limb valgus deformity, increased tibial tuberosity–trochlear groove (TT-TG) distance, and torsional misalignment. The scoring systems described (Patellar Instability Severity [PIS] score and Recurrent Instability of the Patella [RIP] score) provide practical tools that can be used for fast and individualized risk stratification in everyday clinical practice. In patients with a favorable risk profile and consequently low risk of redislocation, conservative treatment should be initiated. However, patients with a high risk of redislocation should be referred to a specialist who will plan the optimal surgical treatment regimen based on the identified combination of existing risk factors.

of existing risk factors (13–17). Trochlear dysplasia, patella alta, patellar tilt, and the tibial tuberosity to trochlear groove (TT-TG) distance are of particular importance here, as these conditions influence patella tracking—as do deformities of the leg axis or abnormal tibial and femoral torsion—and consequently promote instability (14, 18–20) (*Figure 1*). In addition, bilateral instabilities, young age, and the patient's sex appear to influence the risk of redislocation (12). However, since most models consider only a limited number of heterogeneously defined risk factors with variable cut-off values, it is unlikely that consistent recommendations for surgeons providing the initial treatment can be derived from these models (14, 21–23).

The aim of our study was to provide evidence-based recommendations for the treatment of primary patellar dislocation based on a systematic review of the existing literature. We focused on the question which patients could benefit from conservative treatment after first-time patellar dislocation with a low risk of redislocation and in which patients primary surgical treatment should be considered because of a high risk of recurrence. We hypothesized that patients likely to benefit from conservative treatment after first-time patellar dislocation can be identified by individual risk stratification.

Methods

In order to increase transparency and minimize statistical risk of bias, the (revised) assessment of multiple systematic reviews (R-AMSTAR) criteria were applied to the search strategy (24, 25).

Search strategy and selection of studies

A systematic search of the literature was performed using OvidSP (Wolters Kluwer), a full-text database

search engine, in all evidence-based medicine (EBM) databases, and in MEDLINE in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines (26). The literature published until 11 April 2019 was searched. Our search strategy is detailed in *eTable 1*.

Articles were selected based on titles, abstracts, full-text articles, and references of the included full-text articles by 2 independent authors (FJ and KP) and additional articles were identified based on discussions with experts in the field of patellofemoral instability (24, 25). Scientific articles in either English or German were eligible for inclusion. The inclusion and exclusion criteria are listed in the *Box*. Any discrepancies were discussed to reach a consensus. When no consensus could be achieved, a third author (BP) was consulted. The PRISMA statement was chosen for the presentation of the study selection process (27).

Assessment of study quality

The methodological quality of included studies was assessed using the Methodological Index for Non-randomized Studies (MINORS) checklist (28). In the event of disagreement between the two reviewers (FJ, KP), again a third author (BP) was consulted. The Newcastle-Ottawa scale (NOS) was used to assess the risk of bias in included studies (29).

Data analysis/statistics

The redislocation rate, risk factors and related odds ratios (ORs), hazard ratios (HRs) or relative risks (RRs) of redislocation were extracted and summarized descriptively (*Table 1a–c*). A random effects model was calculated for the risk factor “patella alta” based on the adjusted OR from 5 OR-reporting studies (13–15, 17, 30). Further statistical analyses could not be performed for any of the other risk factors due to considerable heterogeneity both of the effect estimates and the cut-off value definitions. Statistical analyses were performed using SPSS Statistics Version 24.0.0.0 (IBM Corporation, IBM Inc., Armonk, NY, USA) and the software R (R Core Team 2019, R Foundation for Statistic Computing, Vienna, Austria). The estimators for τ^2 (method: restricted maximum likelihood) and Higgin's I^2 were used to calculate the degree of heterogeneity in the random effects model.

Results

The R-AMSTAR score of this systematic review was 34/44 points. The initial search identified 185 studies. After removal of duplicates, 174 studies remained. Two further studies were identified by expert discussions; thus, altogether 176 studies were pre-selected. A further 155 studies were excluded after screening by title and abstracts, leaving 21 full-text articles to be assessed for eligibility. Of these, 10 studies were included (*Figure 2*).

Study characteristics

Two case–control studies (13, 14), four retrospective cohort studies (16, 30–32), one prospective cohort

FIGURE 1

Diagram of anatomic risk factors for patellofemoral instability

- a) Patella alta: Determining patellar height using the Insall-Salvati index (A/B) or the Caton-Deschamps index (C/D)
- b) Lateralization of tibial tuberosity determined by the distance between the tibial tuberosity (TT) and the trochlear groove (TG) or between the tibial tuberosity (TT) and the medial border of the posterior cruciate ligament (PCL)
- c) Trochlear dysplasia, categorized in the types A–D based on Dejour's morphological classification
- d) Valgus alignment: The mechanical axis of the lower extremity (line from the center of the femoral head to the center of the ankle) passes through the center of the tibial plateau if the axis of the lower extremity is straight. However, in patients with valgus deformity, as depicted in the diagram, it passes lateral to the center of the tibial plateau.
- e) Patellar tilt, measured as the angle between the patella and the posterior condylar line

study (17), one retrospective comparative study (22), and two retrospective case series (15, 33) were included in this review. Seven studies were of level III evidence (13, 14, 16, 17, 22, 30, 31) and three were of level IV evidence (15, 32, 33). Based on the NOS, the studies were rated with 5 to 9 of 9 possible stars, consistent with a moderate, study design–related risk of bias of the studies included (*eTable 2*).

Redislocation rate

The redislocation rate with conservative treatment was evaluated in all studies and ranged from 17% to 66% (13–15, 17, 22, 30–33). The follow-up periods varied between 1.3 years (15) and 12.4 years (30) (*Table 1a*).

Risk factors for recurrent patellar dislocations

Besides demographic data, such as age and sex, mainly anatomic risk factors were identified. *Table 1b* shows the

rates of the individual risk factors; their influence on redislocation rates is shown in *Table 1c*. Depending on the study cited, the risk increase was reported as OR, HR or RR.

Age

Seven of the 10 studies described patients with skeletal immaturity or young age at the time of primary patellar dislocation as risk factors for recurrence (13–17, 22, 30). In these studies the defined age limits varied between ≤ 16 years and <25 years. Other studies differentiated between patients with open or closed growth plates, regardless of age. Only Sanders et al. reported lower redislocation rates with decreasing age at the time of primary dislocation, in skeletally immature patients (HR 0.77) (33).

Sex

Eight studies evaluated sex as a risk factor for redislocation. Christensen et al. reported a higher redislocation

BOX

Inclusion and exclusion criteria

- **Inclusion criteria**
 - Primary dislocation
 - Conservative treatment
 - Monotrauma (patellar dislocation)
 - Native knee joint
 - Defined risk factors
 - Diagnostic evaluation of risk factors using magnetic resonance imaging
 - Follow-up period ≥ 12 months
 - Reporting of redislocation rates
 - Predictive models
- **Exclusion criteria**
 - Status post knee arthroplasty
 - Previous knee surgery
 - Complex knee injuries
 - Animal studies
 - Cadaver studies
 - Patients with anterior knee pain
 - Interval studies of the same study group
 - Systematic reviews and meta-analyses

risk for girls and young women compared to male patients (OR 1.5) (30). None of the studies found a significant difference between male and female patients (13–17, 22, 33).

Bilateral instability

Two studies investigating whether a history of contralateral dislocation represented a risk factor for redislocation found a threefold increase in the likelihood of redislocation associated with prior contralateral dislocation (14, 15).

Patella alta

The influence of patella alta on patellofemoral instability was evaluated in 8 of the 10 studies. However, there were variations among the studies in the definitions used—either as measured using the Insall-Salvati ratio (ISR) or Caton-Deschamps index (CDI)—and cut-off values (between >1.2 and ≥ 1.3 [ISR] or ≥ 1.3 and >1.45 [CDI]) for patella alta (*Figure 1a*). Seven studies found that patella alta was associated with a significantly increased risk of redislocation (OR ≤ 10.4 /HR ≤ 10.6); only Lewallen et al. did not observe a significant increase (13–15, 17, 22, 30, 33). Statistical analysis of the 5 studies reporting ORs (13–15, 17, 30) yielded a common estimate of the OR of 4.259 with a 95% confidence interval of [1.974, 9.188] and a p-value of <0.001 ; however, there was considerable heterogeneity among the studies (Higgin's $I^2 = 76.51\%$ or $\tau^2 = 0.5764$; *Figure 3*).

Trochlear dysplasia

Trochlear dysplasia was identified in 8 studies as one of the key risk factors for patellar redislocation. Most

studies used Dejour's classification system to grade trochlear dysplasia according to morphology (14, 15, 17, 22, 30, 33). In one study, trochlear dysplasia was defined using the trochlear groove angle (the angle between the lateral and medial trochlear facets) (13). The presence of trochlear dysplasia was associated with ORs between 2.57 (16) and 18.95 (17) or an HR of 23.7 (33), in relation to the redislocation risk.

TT-TG distance

The influence of an pathologically increased tibial tuberosity to trochlear groove (TT-TG) distance on the likelihood of patellar redislocation was evaluated in 7 studies (13, 14, 17, 22, 30, 32, 33). The cut-off value beyond which the TT-TG distance was considered pathological was determined using computed tomography (CT) or magnetic resonance imaging (MRI). Definitions of this cut-off value varied between >14 mm and >20 mm. While one study reported no significant association between TT-TG distance and redislocation rate (13), the remaining studies found ORs between 1.47 (14) and 12.74 (17) or an HR of 18.7 (33) and a RR of 6.4 (32).

Location of MPFL tear

The location of the tear of the medial patellofemoral ligament (MPFL) after first-time dislocation was identified in one study as a predictor of a high redislocation rate (31). During the 7-year follow-up, 32% of all patients with femoral MPFL tear after primary patellar dislocation experienced a redislocation, while a recurrence occurred only in 9% and 0% of patients with intraligamentary and patella-side tears, respectively (31).

Discussion

In this systematic review we identified 10 studies evaluating the risk of redislocation following primary patellar dislocation, using predictive models.

The redislocation rate with conservative treatment varied among studies between 17% and 66% (13–15, 17, 22, 30–33). This may be explained by the heterogeneity of the follow-up periods which varied in duration from 1.3 years (15) to 12.4 years (30).

Among young patients <18 years of age, the redislocation risk was found to be increased (13–15, 17, 30). This risk further increased considerably with decreasing age (<16 years) (OR 11.8) (14). While the state of maturity of the growth plates appeared to make no difference (16), Arendt et al. found an increased risk in patients with not yet completed longitudinal growth (OR 4.05) (13). Only Sanders et al. reported a slightly increased risk with advancing age among adolescents (HR 1.3) (33). Female sex was only associated with a slightly increased redislocation risk in 1 of 4 studies; thus, no clear conclusion can be drawn (16, 22, 30). Two studies showed an increased likelihood of ipsilateral redislocation in patients with a history of contralateral patellar dislocation (OR 3.05–3.17) (14, 15).

TABLE 1 a–c

Included studies: Study characteristics and analyzed risk factors

a) Study designs, sample sizes, follow-up periods, and redislocation rates of the included studies										
Study design	Arendt (13)	Balcarek (14)	Christensen (30)	Hevesi (22)	Jaquith (15)	Lewallen (16)	Sanders (33)	Sillanpää (31)	Yeoh (32)	Zhang (17)
Sample size	Case-control prospective n = 145	Case-control retrospective n = 61	Cohort retrospective n = 584	Comparison retrospective n = 81	Case series retrospective n = 266	Cohort retrospective n = 222	Case series retrospective n = 232	Cohort retrospective n = 53	Cohort retrospective n = 43	Cohort prospective n = 166
Follow up (years)	2	3	12.4	10	1.3	3.1	12	7	2	5
Redislocation rate	42%	66%	36%	47%	35%	38%	45%	17%	30%	36%
b) Frequency of each risk factor in the respective samples										
Young age/ skeletal immaturity	48% ^{*1}	49% ^{*2}	–	52%	–	52% ^{*1}	100% ^{*4}	–	–	72% ^{*3}
Patella alta	–	52% ^{*6}	15% ^{*7}	12% ^{*7}	–	45% ^{*9}	23% ^{*7}	–	–	45% ^{*5}
Trochlear dysplasia	–	100% ^{*11}	17% ^{*11}	41% ^{*11}	–	38% ^{*11}	23% ^{*11}	–	–	65% ^{*11}
TT-TG distance increased	–	43% ^{*12}	–	47%	–	–	–	–	65% ^{*15}	21% ^{*13}
Femoral MPFL tear	9%	–	–	–	–	–	–	66%	–	42%
Female sex	56%	43%	–	53%	55%	46%	52%	0%	53%	55%
Bilateral instability	12%	20%	–	–	–	–	–	–	–	–
c) Influence of various risk factors on patellar redislocation after primary dislocation, shown as odds ratio (OR), hazard ratio (HR), or relative risk (RR)										
Young age/ skeletal immaturity	OR 4.05 ^{*1}	OR 11.2 ^{*2}	OR 2.4 ^{*3}	–	OR 2.23 ^{*1}	HR 1.58 ^{*1}	HR 0.77 ^{*4}	–	–	OR 4.09 ^{*3}
Patella alta	OR 3.00 ^{*5}	OR 1.36 ^{*6}	OR 10.4 ^{*7}	↑ ^{*7}	OR 2.06 ^{*8}	HR 1.29 ^{*9}	HR 10.6 ^{*7}	–	–	OR 8.42 ^{*5}
Trochlear dysplasia	OR 4.87 ^{*10}	OR 4.25 ^{*11}	OR 18.1 ^{*11}	↑ ^{*11}	OR 3.56 ^{*11}	HR 2.57 ^{*11}	HR 23.7 ^{*11}	–	–	OR 7.21 (A) ^{*11} OR 18.95 (B–D)
TT-TG distance increased	–	OR 1.47 ^{*12}	OR 2.1 ^{*13}	↑	–	–	HR 18.7 ^{*14}	–	RR 6.4 ^{*15}	OR 12.74 ^{*13}
Femoral MPFL tear	–	–	–	–	–	–	–	↑	–	OR 6.04
Female sex	–	–	OR 1.5	ns	–	HR 0.8	ns	–	–	–
Bilateral instability	–	OR 3.17	–	–	OR 3.05	–	–	–	–	–

^{*1}Open growth plates/skeletal immaturity; ^{*2}age ≤ 16 years; ^{*3}age < 18 years; ^{*4}younger age; ↑, increased risk, not specified
^{*5}Insall-Salvati index ≥ 1.3; ^{*6}Insall-Salvati index > 1.2; ^{*7}Caton-Deschamps index ≥ 1.3; ^{*8}Caton-Deschamps index > 1.45; ^{*9}Insall-Salvati index or Caton-Deschamps index > 1.2; ^{*10}trochlear groove angle ≥ 154°;
^{*11}trochlear dysplasia according to Dejour's classification (types A–D); ^{*12}TT-TG distance ≥ 16 mm; ^{*13}TT-TG distance > 20 mm; ^{*14}TT-TG distance > 14 mm
 HR, hazard ratio; OR, odds ratio; MPFL, medial patellofemoral ligament; ns, non-significant; TT-TG, tibial-tuberosity to trochlear groove; RR, relative risk

FIGURE 2

Study selection according to PRISMA statement (27)

PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; MRI, magnetic resonance imaging

Most studies evaluating the risk of redislocation focused on anatomic risk factors (30).

With an ISR of ≥ 1.3 (OR 3.0/8.4) (13, 17) and >1.2 (OR 1.36) (14), respectively, or a CDI of ≥ 1.3 (OR 10.4/HR 10.6), patella alta was one of the main risk factors for redislocation (22, 30, 33). Interestingly, in MRI studies, Arendt et al. found an increased redislocation risk in patients with abnormal ISR, but not with abnormally increased CDI (13). However, measurements of patellar height using MRI are known to result in higher values compared to radiographs, with mean differences of 0.18 (CDI) and 0.11 (ISR), respectively, so that the cut-off value of the CDI in this study was possibly biased by the way the CDI was determined (34).

A second major risk factor was the presence of trochlear dysplasia, which was found to increase the risk of redislocation already in mild cases (trochlear angle $>145^\circ$ and $>154^\circ$, respectively; Dejour's type A) (13, 14, 17, 22). Increasing severity (types B to D) was associated with a considerable increase in risk (7.21 versus OR 18.95) (17). This finding was confirmed by several studies, but with variable OR or HR (13, 16, 30, 33) which can be attributed to the high incidence of dysplastic trochleae (85% according to Dejour) (18) in conjunction with only moderate inter-rater reliability of the classification system (35). In addition, many studies with remarkably high OR or

FIGURE 3

Meta-analysis with random-effects model to analyze influence of risk factor "patella alta"; CI, confidence interval; RE, random effects

HR values did not further differentiate the corresponding subcategories (17, 30, 33).

The influence of a pathologically increased TT-TG distance has attracted considerable attention, but the cut-off values reported in the literature vary. As the result of different flexion angles of the knee in CT scans and MRI, positioning-related measuring differences can occur, for example due to tibial (external) final rotation in full extension (36). While TT-TG distances between 9.4 and 13.6 mm are considered normal for adults (37, 38), Balcarek et al. identified a TT-TG of ≥ 16 mm as a critical cut-off value (OR 1.47) (14), a finding that was indirectly confirmed by Hevesi et al. (22). The redislocation risk was found significantly increased in patients with TT-TG distances of ≥ 20 mm (OR up to 12.74 or HR of 18.7). In our opinion, this value should be the cut-off value for conservative treatment, especially if there are clinical signs of impaired patella tracking (17, 30, 33). Furthermore, the distance between the tibial tubercle and the medial border of the posterior cruciate ligament (PCL) (TT-PCL distance) has been postulated as an alternative to the TT-TG distance (36). Measurement of the TT-PCL distance is independent of any rotation in the knee joint. Furthermore, it can be of advantage in patients with conditions such as trochlear dysplasia where the trochlear groove cannot be clearly identified. A TT-PCL distance ≥ 24 mm is considered abnormal (36).

The analysis of the included literature shows that the redislocation risk cannot be assessed using isolated risk factors. On average 1.3 years after first-time dislocation, Jaquith et al. found a risk of recurrence of 56% in children with trochlear dysplasia, which further increased to 88.4% in patients with concomitant patella alta and a history of contralateral dislocation (15). Based on Patella Instability Severity (PIS) score data, Balcarek et al. found a 5-fold

increased risk of redislocation when the combination of identified risk factors resulted in a score ≥ 4 (*eTable 3a*) (14). Similarly, the Recurrent Instability of the Patella (RIP) score can be utilized to predict the redislocation risk, with a range from 0% (0–1 points) to 80% (4–5 points) (*eTable 3b*) (22). Finally, Arendt et al. showed that growing children with patella alta and a trochlear groove angle $\geq 154^\circ$ had a significantly higher redislocation risk (78.5%) compared to fully grown adolescents without risk factors (7.7%) (13).

The influence of isolated anatomic risk factors is particularly strong if they result in impaired patellofemoral kinematics (maltracking), such as in trochlear dysplasia, pathologically increased TT-TG distance, or patella alta (14, 17, 30, 33, 39). Even though prospective validation of the cited scoring systems has yet to be performed, their clinical use can already be recommended based on existing evidence. While each one of the analyzed and described scoring systems cover only a selection of all potentially relevant factors, our systematic review offers a broad evaluation of risk factors described in the literature. We found that patients >18 years of age with CDI/ISR <1.2 , a TT-TG distance <16 mm and a trochlear sulcus angle $<145^\circ$ without contralateral patellar dislocation had the lowest likelihood of recurrence. In these patients, the risk of redislocation was 0 to 5.8% in the first year and 13.8% in children >14 years (13, 15, 16, 22). At least one anatomic risk factor is present in 90% of all first-time cases of displacement. Depending on the underlying risk factor (22), recurrence rates of 22.7% after 2 years to 0% after 10 years are found (13). In children with a single risk factor, the risk of redislocation is 30% (15).

Limitations

The levels of evidence among the included studies are generally low, since the randomized controlled trials (RCTs) reported in the literature did not meet the inclusion criteria required for our research question. Due to the heterogeneity of the definitions and cut-off values of the risk factors assessed, a meta-analysis to statistically underpin the significance of our review could only be performed for the risk factor patella alta. Furthermore, risk factors such as valgus deformity, torsional deformity, or a low lateral trochlear inclination angle (19) have not been addressed in any of the published studies.

Conclusion

Precise identification of existing risk factors is crucial for individual and risk-based counselling of patients after primary patellar dislocation. Both the PIS score and the RIP score are suitable tools for fast risk stratification. In everyday clinical practice, they can be used to plan the further treatment by broadly categorizing individual risk profiles. Patients with a low-risk profile can benefit from conservative treatment due to their low redislocation risk. In patients with a high-risk profile, primary surgical treatment should be considered in

Key messages

- When deciding between conservative and surgical treatment for primary patellar dislocation, it is essential to identify risk factors for redislocation.
- Besides demographic characteristics, such as age and sex, the redislocation risk depends largely on anatomic risk factors.
- Multiple risk factors in combination increase the risk of patellar redislocation.
- Patients with primary patellar dislocation and low-risk profile are at a low risk for redislocation; thus, they are potential candidates for conservative treatment.
- Simple tools for fast risk stratification are available to support individual counselling of patients in everyday clinical practice.

order to prevent osteochondral injuries caused by recurrent patellar dislocation over the long-term. Besides discussing with patients their respective individual risk profile in detail, it is highly recommended to involve a specialist in the field of patellofemoral instability in order to find a suitable treatment strategy.

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Conflict of interest statement

PD Dr. Balcarek received lecture fees from Otto Bock, Medi, and Arthrex. Dr. Dirisamer received consultancy fees and lecture fees from Arthrex. The remaining authors declare that no conflict of interests exists.

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► Supplementary material

eTables:

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Supplementary material to:

Conservative Versus Surgical Treatment for Primary Patellar Dislocation

A Systematic Review to Guide Risk Stratification

by Jannik Frings, Peter Balcarek, Philippe Tscholl, Michael Liebensteiner, Florian Dirisamer, and Paola Koenen on behalf of the AGA Knee Patellofemoral Committee

Dtsch Arztebl Int 2020; 117: 279–86. DOI: 10.3238/arztebl.2020.0279

eTABLE 1

Search strategy

Step	Search terms
1	(prim* OR (first adj1 time)).mp.
2	((recurr* adj1 instab*) OR (second* adj2 time adj2 disl*) OR (persist* adj1 instab*) OR (recurr* adj1 disloc*) OR redisl* or re-disl*).mp.
3	(dislocat* OR instab* OR redislocat* OR re-dislocat*).mp.
4	patella*.mp.
5	3 AND 4

eTABLE 2

Risk of bias of included studies according to Newcastle-Ottawa scale (NOS)

First author (reference)	Study design	Selection	Comparability	Exposure or endpoint assessment	Total score
Arendt (13)	Case-control, prospective	***	**	***	8/9
Balcarek (14)	Case-control, retrospective	****		**	6/9
Christensen (30)	Cohort, retrospective	****	**		6/9
Hevesi (22)	Comparison, retrospective	****	**	***	9/9
Jaquith (15)	Case series, retrospective	**		***	5/9
Lewallen (16)	Cohort, retrospective	****		**	6/9
Sanders (33)	Case series, retrospective	****	**	*	7/9
Sillanpää (31)	Cohort, retrospective	****		**	6/9
Yeoh (32)	Cohort, retrospective	****		**	6/9
Zhang (17)	Cohort, prospective	****	**	**	8/9

The individual studies are assessed with regard to selection, comparability, and exposure/endpoint. If the risk of bias is low, one star is awarded; the maximum number of stars that can be achieved is 9.

eTABLE 3

Risk stratification models

a) Patellar Instability Severity (PIS) score (14).
A PIS score ≤ 4 represents a low risk of redislocation, while a score ≥ 4 is associated with a high risk of recurrence.

Risk factor	Points
Age	
>16 years	0
≤ 16 years	1
Contralateral instability or connective tissue disease	
No	0
Yes	1
Trochlear dysplasia	
No	0
Mild (type A)*	1
Severe (types B–D)*	2
Patellar height according to Insall-Salvati	
≤ 1.2	0
>1.2	1
TT-TG distance	
<16 mm	0
≥ 16 mm	1
Patellar tilt (°)	
$\leq 20^\circ$	0
>20°	1
Total	0–7

b) Recurrent Instability of the Patella score (RIP score) (22).
Classification into low risk (0–1 point), intermediate risk (2–3 points), and high risk (4–5 points) for patellar redislocation.

Risk factor	Points
Age <25 years	2
Open growth plates	1
Trochlear dysplasia (types A–D)*	1
TT-TG/patellar height ≥ 0.5	1
Total	0–5

* According to Dejour's classification