Sulcus-Deepening Trochleoplasty as an Isolated or Combined Treatment Strategy for Patellar Instability and Trochlear Dysplasia: A Systematic Review

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**Purpose:** To highlight the indications and outcomes for sulcus-deepening trochleoplasty, when used as an isolated procedure as well as in combination with other stabilization techniques for patellar instability. **Methods:** We performed a systematic review focused on outcomes and complications following trochleoplasty performed either as an isolated procedure or in combination with other procedures to address patellar instability. Inclusion criteria included studies in English that reported on outcomes following primary open trochleoplasty, including Kujala scores and recurrent instability or dislocation events. **Results:** Twelve papers including 702 patients who underwent sulcus-deepening trochleoplasty were included. A total of 504 patients underwent isolated sulcus-deepening trochleoplasty, whereas 198 patients underwent trochleoplasty in combination with 1 or more additional stabilization procedures. In total, 67% of patients were female compared with 33% male. The procedure was done as a primary surgical intervention 74% of the time. Postoperative Kujala scores for isolated trochleoplasty ranged from 80 to 92, whereas those for combined stabilization procedures ranged from 76 to 95. The dislocation rate among the studies ranged from 0 to 8%. There was a persistent J-sign in 0 to 12% of treated knees among all studies, and a persistent apprehension test in 0 to 29% of treated knees. Return to play ranged from 65% to 83% in studies in which this was reported as an outcome. **Conclusions:** Sulcus-deepening trochleoplasty performed for recurrent patellar instability in the setting of trochlear dysplasia results in improved Kujala scores and a low redislocation rate, when performed as an isolated procedure or in combination with other stabilization procedures. Greater-level evidence is needed to better evaluate the overall efficacy of this procedure in addressing patellar instability. **Level of Evidence:** Level of Evidence, IV; Systematic review of level III and IV studies

Patellar instability, a debilitating condition that affects approximately 6 of 100,000 individuals in the United States, has several anatomic etiologies, including medial patellofemoral ligament (MPFL) complex incompetence, trochlear dysplasia, an excessively externally rotated or proximally located tibial tuberosity, insufficiency of the vastus medialis obliquus and quadriceps musculature, and excessive internal rotation of the femur. Diverse procedures exist to address these differing etiologies, including repair or reconstruction of the MPFL, trochleoplasty, tibial tubercle osteotomy, and femoral osteotomy. The successful treatment of patellar instability continues to be a challenge, given the multiple etiologies that may be responsible for the pathology. Although MPFL reconstruction and tibial tubercle osteotomies are common approaches for patellar stabilization, trochlear dysplasia continues to be a risk factor for poor surgical outcomes in many series.
Trochlear dysplasia is defined functionally as shallowness of the trochlea that may predispose to patellar maltracking and instability with knee flexion.\textsuperscript{5,6} It has been reported to be present in more than 80% of patients with patellar instability.\textsuperscript{5} The following 4 anatomic variations based on radiographic evaluation of a lateral view of the knee have been described: presence of a crossing sign, which is present when the contour of the trochlear floor intersects with or protrudes anterior to the contour of the lateral femoral condyle (type A); a crossing sign with a supratrochlear spur (type B); a crossing sign with a double-contour sign reflecting a hypoplastic medial femoral condyle (type C); and absence of the trochlea, when all three signs are present (type D).\textsuperscript{5-7} In addition, on the Merchant view the sulcus angle can be calculated: an angle greater than 145° is defined as dysplastic.\textsuperscript{6,8} Despite the high prevalence of trochlear dysplasia in patients with patellar instability, the surgical treatment of trochlear dysplasia with a trochleoplasty has been rarely used due to the highly technical nature of the procedure and some concern for disruption of the articular cartilage.\textsuperscript{9}

There are 3 principal types of trochleoplasty: lateral facet elevation, sulcus deepening, and recession wedge, which are often performed in combination with bony or soft-tissue corrective procedures.\textsuperscript{2-4,6,9-12} The modern sulcus-deepening technique was described by Dejour in 1987 and additionally modified by Bereiter and Gautier in 1994.\textsuperscript{2,13-16} Dejour et al. suggested that the sulcus-deepening procedure may be most appropriate for type B and type D dysplasia, whereas type C dysplasia may be more amenable to the lateral facet–elevating technique.\textsuperscript{2,5,7} In the modified sulcus-deepening procedure described by Bereiter and Gautier, a cartilage “flake” is elevated in the trochlear groove and a burr or straight osteotome is used to remove the underlying bone to effectively deepen the trochlear groove, after which the cartilage flake is replaced and secured such that it plastically conforms over the contour of the deepened groove.\textsuperscript{2,3,9,16} More recently, a variation of this approach has been described in which a thick osteochondral flap is elevated rather than a thin cartilage flake.\textsuperscript{14}

A sulcus-deepening technique is the most common form of trochleoplasty performed.\textsuperscript{7} Compared with other patellar-stabilization techniques such as MPFL reconstruction and tibial tubercle transfer, less evidence is available regarding trochleoplasty. The purpose of this systematic review is to highlight the indications and outcomes for sulcus-deepening trochleoplasty, when used as an isolated procedure as well as in combination with other stabilization techniques for patellar instability. Given the high prevalence of trochlear dysplasia among individuals with recurrent patellar instability, we hypothesize that trochleoplasty alone or in combination with additional bony or soft-tissue techniques will prove an effective method for reducing the occurrence of patellar instability and improving patient-reported outcomes.

**Methods**

A systematic review and meta-analysis were performed according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

**Study Eligibility**

Inclusion criteria were studies in the English language (levels of evidence 1-4) that evaluated standardized patient-reported outcome measures as well as recurrent dislocation or instability following trochleoplasty as a surgical treatment for patellar instability and/or trochlear dysplasia. Surgical treatment was set to include sulcus-deepening trochleoplasty as either an isolated or combined procedure used in treatment. Exclusion criteria included reviews of the literature, expert opinions, nonclinical studies, isolated case reports, and clinical series that did not involve commonly used, validated outcomes scoring systems or report on clinical and/or functional patient outcome measures.

**Literature Search**

An electronic search was performed in MEDLINE via PubMed and Embase. The search included the key words “trochleoplasty” OR “trochlear dysplasia.” The final search was performed on March 20, 2020.

**Study Selection and Data Abstraction**

Three authors (M.R.D., T.E.D., R.D.F.) independently selected relevant articles based on title from the search results. The abstracts of all titles chosen by any one of the authors were then analyzed and data were recorded in spreadsheet format.

**Risk of Bias Assessment**

Study bias was analyzed using the Methodological Index for Non-Randomized Studies (MINORS) criteria, a validated instrument of assessment of non-randomized studies, by 2 independent reviewers (M.R.D., S.A.).\textsuperscript{17}

**Data Analysis**

Data extraction followed a standardized protocol developed before the search. The pertinent characteristics of each study were collected, including study design, year of publication, patient number, and level of evidence, as well as the characteristics of study participants (age, sex, primary vs revision surgery). Treatment technique was recorded, specifying the type of sulcus-deepening trochleoplasty performed, and primary clinical outcome measures including Kujala score and re-dislocation rate. Markers of clinical (physical examination findings and return-to-sport) and radiologic
outcomes were also documented, in addition to complications. Given the heterogeneity of outcomes and low level of available evidence on this subject (Table 1), a formal meta-analysis could not be performed, although results of isolated trochleoplasty compared with trochleoplasty as part of a combined stabilization procedure were considered qualitatively. Redislocation rate following surgery was recorded, and the Kujala score was the most frequently reported clinical outcome measure.

Results

Using the study-acquisition algorithm detailed in Figure 1, we identified 888 studies related to the keywords “trochleoplasty” OR “trochlear dysplasia” and narrowed our search to 12 studies related to sulcus-deepening trochleoplasty and its impact on patient-reported outcomes and patellar instability, as well as complications encountered (Table 1). Final studies were selected based on inclusion of all or most of the following metrics: (1) use of standardized patient-reported outcome scores such as the Kujala score, (2) inclusion of dislocation rates as an outcome measure, (3) inclusion of clinical outcome measures such as presence of a J-sign or positive apprehension test, and (4) inclusion of any relevant complications related to the procedure. All studies had lower quality assessment as per MINORS criteria, with each study being non-comparative with a score <16 (Table 1). All included studies were either Level III or Level IV evidence (Table 1). Among the 12 studies included, there were 702 cases of trochleoplasty performed on 639 patients, 67% of whom were female (Table 2). Trochleoplasty was performed as a first-time surgical intervention in 74% of cases and was an isolated stabilization intervention in 33.9% of cases.

As the Kujala scoring questionnaire was the most widely used patient-reported clinical outcomes measure across studies, it was considered qualitatively between trochleoplasty that was performed as an isolated intervention and trochleoplasty as part of a combined stabilization procedure. Mean Kujala scores ranged from 81 to 92 postoperatively in the isolated trochleoplasty group and 76 to 95 in the combined group. Recurrent

| Study Title                                                                 | First Author       | Year | LOE | MINORS Score |
|----------------------------------------------------------------------------|--------------------|------|-----|--------------|
| Combined Trochleoplasty and Medial Patellofemoral Ligament Reconstruction for Recurrent Patellar Dislocations in Severe Trochlear Dysplasia | Nelitz             | 2013 | III | 8            |
| Trochleoplasty as a Solitary Treatment for Recurrent Patellar Dislocation Results in Good Clinical Outcome in Adolescents | Camathias          | 2016 | IV  | 8            |
| Sulcus Deepening Trochleoplasty for Patellofemoral Instability: A Series of 34 Cases After 15 Years Postoperative Follow-up | Rouanet            | 2015 | IV  | 8            |
| A Prospective Evaluation of Trochleoplasty for the Treatment of Patellofemoral Dislocation and Instability | Uting              | 2008 | IV  | 12           |
| Trochleoplasty for Recurrent Patellar Dislocation in Association With Trochlear Dysplasia. A 4- to 14-Year Follow-Up Study | Von Knoch          | 2006 | IV  | 10           |
| Trochleoplasty for Patellar Instability due to Trochlear Dysplasia: A Minimum 2-Year Clinical and Radiological Follow-Up of 19 Knees | Schöttle           | 2005 | IV  | 8            |
| Midterm Results of Comprehensive Surgical Reconstruction Including Sulcus-Deepening Trochleoplasty in Recurrent Patellar Dislocations With High-Grade Trochlear Dysplasia | Ntagiopoulos       | 2013 | IV  | 8            |
| No Growth Disturbance After Trochleoplasty for Recurrent Patellar Dislocation in Adolescents With Open Growth Plates | Nelitz             | 2018 | IV  | 8            |
| Trochleoplasty With a Flexible Osteochondral Flap: Results From an 11-Year Series Of 214 Cases | Metalice           | 2017 | IV  | 8            |
| Trochleoplasty Is a Viable Option for Patellar Instability in Patients With Severe Trochlear Dysplasia: Early Outcomes Analysis of the U.S. Experience | Diduch             | 2017 | IV  | 10           |
| Classification of Trochlear Dysplasia as Predictor of Clinical Outcome After Trochleoplasty | Fucentese          | 2011 | III | 11           |
| Thick-Osteochondral Flap Deepening Trochleoplasty for Patellar Instability | Donel              | 2016 | IV  | 12           |

LOE, level of evidence; MINORS, Methodological Index for Non-Randomized Studies.
Discussion

Overall, Kujala scores increased postoperatively compared with preoperatively in cases in which trochleoplasty was performed as an isolated or combined procedure. A 2019 case series of 211 isolated MPFL reconstructions reported an average Kujala score of 88.8 postoperatively.29 Similarly, a 2018 case series by Liu et al.30 of anteromedialization tibial tubercle osteotomy in 48 patients found average postoperative Kujala scores of 82.6. Thus, it appears that on average, Kujala scores for either isolated trochleoplasty or combined stabilization surgery involving trochleoplasty are similar to previously reported scores for other knee stiffness or loss of flexion after surgery (Table 5). Diduch et al.26 reported an arthrofibrosis rate of 18% requiring manipulation under anesthesia in their series of 49 cases. Rouanet et al.20 reported stiffness limiting flexion to less than 90° in 8 of 34 patients (24%). In addition, over the 15-year follow-up period, 6 of 34 knees were revised to either a patellofemoral or total knee arthroplasty, and 1 of 34 underwent revision by tibial tubercle osteotomy given persistent instability.20 Nelitz et al.24 in 2018 reported that 4 of 18 patients had either reduced flexion requiring further rehabilitation, adhesions requiring repeated arthroscopy, or a persistent flexion contracture of up to 5° at final follow-up. Wound-related complications were rare, reported in 2 of 59 cases by Utting et al.21 and 1 of 44 cases in Fucentese et al.27

Table 2. Demographic Baseline Data Including Sex, Preoperative Dislocations, and Type (Primary Versus Revision) of Procedure

| Study                 | Patients (Knees) | Sex | Dislocations Before Surgery | Primary vs Revision Stabilization Procedure |
|-----------------------|------------------|-----|-----------------------------|---------------------------------------------|
| Nelitz et al., 2013   | 23 (26)          | M: 10 F: 16 | >2                          | 26/26 primary                               |
| Camathias et al., 2016 | 44 (50)         | M: 20 F: 30 | Recurrent dislocations not responding to nonoperative treatment for 6 mo | 50/50 primary                               |
| Rouanet et al., 2015  | 34               | M: 10 F: 24 | Average of 6 dislocations per patient preoperatively | 21/34 primary; 13/34 revision               |
| Utting et al., 2008   | 54 (59)          | M: 15 F: 44 | Unspecified                 | 43/59 primary, 16/59 revision               |
| Von Knoch et al., 2006 | 38 (45)         | M: 22 F: 16 | Unspecified                 | 30/45 primary, 15/45 revision               |
| Schöttle et al., 2005 | 19               | M: 4 F: 15 | ≥2 dislocations, or 1 + persistent apprehension sign | 14/19 primary, 5/19 revision                |
| Ntagiopoulos et al., 2013 | 27 (31)      | M: 14 F: 13 | >3 dislocations              | Not stated                                  |
| Nelitz et al., 2018   | 18 (18)          | M: 6 F: 12 | >2                          | 12/12 primary                               |
| Metcalfe et al., 2017 | 185 (214)       | M: 52 F: 133 | Unspecified                | 154/214 primary, 60 revision                |
| Diduch et al., 2017   | 43 (49)          | M: 10 F: 39 | Unspecified                 | 26/49 primary, 23/49 revision               |
| Fucentese et al., 2011 | 38 (44)        | M: 11 F: 33 | ≥2 dislocations, or 1 with persistent apprehension | 31/44 primary, 13/44 revision               |
| Donel et al., 2016    | 90 (107)         | M: 36 F: 54 | >1 dislocation, failed conservative management or prior surgery | 64/107 primary surgery, 43/107 revision     |

F: female; M: male.
well-established stabilization techniques. Among the studies included in this review, more than one half of cases involved an isolated sulcus-deepening technique without other concurrent stabilization procedures, and surgery was more frequently performed as a primary surgical intervention than a revision surgery. The shared purpose of trochleoplasty, MPFL reconstruction, and tibial tubercle osteotomy is to prevent redislocation of the patella and treat persistent instability. Thus, one important focus of this review was to assess redislocation rates, in addition to persistence of clinical instability as evidenced by the J-sign and positive apprehension test. We found that, overall, there was a low dislocation rate among all cases involving trochleoplasty as either an isolated or combined procedure, ranging from 0 to 8%. In addition, we found that the persistence of a J-sign after surgery was a relatively rare occurrence, ranging from 0 to 12%, whereas a positive patellofemoral apprehension test was more common postoperatively, ranging from 0 to 29%. One perceived benefit of trochleoplasty compared with other stabilization techniques is that it directly addresses the bony deformity involved in trochlear dysplasia that contributes to instability. However, a recent case series by Liu et al.31 of 121 isolated MPFL reconstructions performed in patients with Dejour B, C, or D trochlear dysplasia demonstrated mean Kujala scores of 90 and a total of 3 of 121 redislocations over an average follow-up of 44 months. Thus, even in patients with trochlear dysplasia, soft-tissue procedures may prove to be effective in improving clinical outcomes and preventing redislocation with appropriate patient selection.

A topic of recent interest is the use of trochleoplasty as an isolated versus combined procedure in addressing patellar instability. Ren et al.32 performed a systematic review of 192 cases comparing isolated trochleoplasty to that performed in conjunction with MPFL reconstruction, and found a significantly lower redislocation rate with the combined procedure.

### Table 3. Primary Outcomes Including Type of Procedure (Isolated Trochleoplasty Versus Combined Procedure), Kujala Scores, and Redislocation Rates

| Study                  | No. Isolated Trochleoplasty | No. Combined Procedures | Kujala (Isolated) | Kujala (Combined) | Redislocation (Isolated) | Redislocation (Combined) | Mean Follow-up Length, y |
|------------------------|-----------------------------|-------------------------|-------------------|------------------|------------------------|--------------------------|--------------------------|
| Nelitz et al., 201318  | 0/26                        | 26/26                   | —                 | 79 preoperative  | 0/26 (0%)              | 1/50 (2%)                | 2.5                      |
|                        |                             |                         |                   | 90 follow-up     |                        |                          |                          |
| Camathias et al., 201619 | 50/50                      | 0/50                    | 71 preoperative   | 61 postoperative | 0/34 (0%)              | 1/159 (1.7%)             | 2.75                     |
|                        |                             |                         | 92 postoperative  | Diff = 21       |                        |                          |                          |
| Rouanet et al., 201520 | 17/34                       | 17/34                   | —                 | 81 postoperative | 0/34 (0%)              | —                        | 7                        |
| Utting et al., 200821  | 32/59                       | 27/59                   | —                 | 62 preoperative  | 1/59 (1.7%)            | —                        | 2                        |
|                        |                             |                         |                   | Diff = 14       |                        |                          |                          |
| Von Knoch et al., 200614 | 0/45                       | 45/45                   | —                 | 94.9             | 0/45 (0%)              | —                        | 8.3                      |
| Schötte et al., 200522 | 19/19                       | 0/19                    | 56 preoperative   | 0/19 (0%)       | —                      | —                        | 3                        |
|                        |                             |                         | 80 postoperative  | Diff = 24       |                        |                          |                          |
| Ntagiopoulos et al., 201323 | 0/27                    | 27/27                   | —                 | 59 preoperative  | 0/27 (0%)              | —                        | 7                        |
|                        |                             |                         |                   | 87 postoperative |                        |                          |                          |
|                        |                             |                         | Diff = 28        |                |                        |                          |                          |
| Nelitz et al., 201824  | 0/18                        | 18/18                   | —                 | 67 preoperative  | 0/18 (0%)              | —                        | 2.3                      |
|                        |                             |                         |                   | 89.5 postoperative |                        |                          |                          |
|                        |                             |                         | Diff = 22.5      |                |                        |                          |                          |
| Metcall et al., 201725 | 36/224                      | 188/224                 | —                 | 51.5 preoperative| 16/199 (8.0%)          | —                        | 4.43                     |
|                        |                             |                         |                   | 82.5 postoperative|                        |                          |                          |
|                        |                             |                         | Diff = 31        |                |                        |                          |                          |
| Diduch et al., 201726  | 0/49                        | 49/49                   | —                 | 54.5  preoperative| 0/49 (0%)              | —                        | 0.88                     |
|                        |                             |                         |                   | 82.5 postoperative|                        |                          |                          |
|                        |                             |                         | Diff = 28        |                |                        |                          |                          |
| Fucentese et al., 201127 | 44/44                      | 0/44                    | 68 preoperative   | 1/44 (2.2%)    | —                      | —                        | 4 (median)               |
|                        |                             |                         | 90 postoperative  | Diff = 22      |                        |                          |                          |
| Donel et al., 201628   | 40/107                      | 67/107                  | —                 | 63 preoperative  | —                      | —                        | 6                        |
|                        |                             |                         |                   | 79 postoperative |                        |                          |                          |
|                        |                             |                         | Diff = 16        |                |                        |                          |                          |

Diff, difference; pre, preoperative; post, postoperative.
Balcarek et al.\textsuperscript{13} further performed a meta-analysis comparing isolated MPFL reconstruction to MPFL reconstruction performed with trochleoplasty and similarly found that the combined procedure dislocation rate was significantly lower at 2.1% compared with 7% in the isolated MPFL group. The study by Metcalle et al.\textsuperscript{25} included in this review is the largest case series of sulcus-deepening trochleoplasty performed to date, of which the majority of surgeries were performed as combined procedures involving trochleoplasty and a soft-tissue balancing procedure. Of note, this study also reported the highest redislocation rate postoperatively, at 8%.\textsuperscript{25} Nine of 16 of the redislocations occurred in the first half of the surgeries performed, and the remainder in the second half, suggestive of the effect of a technical learning curve, if present, is minimal according to the authors.\textsuperscript{25}

Among the studies included, the most common indication for including trochleoplasty in a surgical intervention was recurrent patellar instability, frequently defined as greater than 2 dislocation events, or a single dislocation event with a persistent apprehension sign on examination. Additionally, most studies considered the radiographic presence of Dejour trochlear dysplasia in the setting of recurrent dislocations as an indication for trochleoplasty. A consideration against performing trochleoplasty as an isolated stabilization procedure is the risk of arthrofibrosis and decreased post-operative range of motion, as well as the risk of radiographic progression of patellofemoral arthritis that it carries.\textsuperscript{16-21,24,26,34} Although dislocation rates with trochleoplasty may be similar to other stabilization procedures such as MPFL reconstruction, the risk of limited range-of-motion and flexion contracture post-operatively may be more prevalent with trochleoplasty. Song et al.\textsuperscript{15} performed a systematic review of trochleoplasty procedures in 2014 and found that there was a lower patellar redislocation rate in procedures involving trochleoplasty as well as a lower percentage of radiographic patellofemoral osteoarthritis (Iwano grade 2 or greater) compared with nontrochleoplasty procedures; however, there was an inferior outcome with respect to range of motion at follow-up. In the present review, however, radiographic progression of arthritis was a commonly cited outcome after trochleoplasty, with Rouanet et al.\textsuperscript{20} noting 97% of patients having developed some degree of patellofemoral arthritis over the 15-year follow-up period, the longest follow-up period included in this review.

Given the risk of postoperative stiffness following trochleoplasty, postoperative rehabilitation protocols must balance protection of bony healing with adequate range of motion. While specific descriptions of rehabilitation protocols were not consistently included in the studies analyzed, Carstensen et al.\textsuperscript{16} published a recent case series on postoperative arthrofibrosis following trochleoplasty, in which patients began physical therapy three days after their index procedure. During the first 2 weeks after surgery, patients were kept 50% weight-bearing, after which time they were advanced to full weightbearing. Flexion was limited 0° to 70° for weeks 1 and 2 postoperatively, then advanced to 90° of flexion for weeks 3 and 4, before being advanced to full range of motion.\textsuperscript{36} Even with the early initiation of this protocol, 11 of 62 knees developed arthrofibrosis and underwent manipulation under anesthesia within 3 months of the index procedure, with 9 of these patients subsequently requiring arthroscopic lysis of adhesion. Following

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**Table 4. Clinical (Including Physical Examination and Return to Sport) and Radiologic Outcomes**

| Study                  | Persistent J Sign | Persistent Apprehension | Return to Sport                                                                 | Radiological Parameters               |
|------------------------|-------------------|-------------------------|--------------------------------------------------------------------------------|--------------------------------------|
| Nelitz et al., 2013\textsuperscript{18} | 0/26 (0%)         | –                       | 1 returned to higher level, 16 to same level, 6 to lower level, 17/26 (65.4%) resumed same level or higher | –                                    |
| Camathias et al., 2016\textsuperscript{19} | 6/50 (12%)        | 8/50 (16%)              | –                                                                               | 97% with mild radiographic arthritis over 15 years |
| Rouanet et al., 2015\textsuperscript{20} | –                 | 10/34 (29.4%)           | 36/54 (66.7%) returned to sport                                                  | –                                    |
| Utting et al., 2008\textsuperscript{21}  | –                 | –                       | –                                                                               | 2/45 positive crossing sign           |
| Von Knoch et al., 2006\textsuperscript{14} | –                 | –                       | 4/19 (21.0%)                                                                   | 3/19 positive crossing sign (grade I) |
| Schöttle et al., 2005\textsuperscript{22} | –                 | –                       | –                                                                               | –                                    |
| Ntagiopoulos et al., 2013\textsuperscript{23} | 0/31 (0%)         | 6/31 (19.4%)            | –                                                                               | –                                    |
| Nelitz et al., 2018\textsuperscript{24} | 1/18 (5.5%)       | 3/18 (16.7%)            | 145/173 (83.4%) resumed sport/activity                                            | 6/199 radiographic OA                 |
| Metcalle et al., 2017\textsuperscript{25} | –                 | –                       | 35/43 (81.4%) returned to sport                                                  | 16/44 with radiographic deterioration to OA |
| Diduch et al., 2017\textsuperscript{26}  | 0/49 (0%)         | 0/49 (0%)               | 11/44 (25%)                                                                    | –                                    |
| Fucentese et al., 2011\textsuperscript{27} | –                 | 11/44 (25%)             | –                                                                               | –                                    |
| Donel et al., 2016\textsuperscript{28}   | –                 | –                       | –                                                                               | –                                    |

OA, osteoarthritis.
treatment approach that carefully takes into account the pathoanatomy and biomechanics that result in an individual’s recurrent patellar dislocations. Based on the present data, we would recommend cautious consideration of trochleoplasty as part of an individualized, combination approach to patellar stabilization in patients with refractory instability and evident trochlear dysplasia, for whom an isolated soft-tissue procedure such as MPFL reconstruction may not fully address their underlying patoanatomy resulting in instability.

**Limitations**

This review has several limitations. Trochleoplasty as a treatment for patellofemoral instability is relatively sparse compared with other more common stabilization techniques such as MPFL reconstruction and tibial tubercle osteotomy, and thus the studies included were all nonrandomized case series. Due to the relative lack of higher-level studies currently available and inconsistent data reporting, a meta-analysis could not be performed, and weighted averages of outcome measures could not be presented due to the risk of introducing bias. Given the nonrandomized nature of the cases included in the review, it is not possible to control for all variables that may contribute to the outcomes reported. There is also heterogeneity in the surgical technique in sulcus-deepening trochleoplasty between studies, with differences in the shape of the bony resection between the techniques described by Masse, Dejour et al., and Bereiter and Gautier, as well as variations in the use of additional procedures. Greater-level evidence is needed to better evaluate the overall efficacy of this procedure in addressing patellar instability.

**Conclusions**

Sulcus-deepening trochleoplasty performed for recurrent patellar instability in the setting of trochlear dysplasia results in improved Kujala scores and a low redislocation rate, when performed as an isolated procedure or in combination with other stabilization procedures. Greater-level evidence is needed to better evaluate the overall efficacy of this procedure in addressing patellar instability.
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