Original Article

Grooveplasty Compared With Trochleoplasty for the Treatment of Trochlear Dysplasia in the Setting of Patellar Instability

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Purpose: To compare the clinical efficacy in the resolution of patellar instability, patient-reported outcomes (PROs), and complication and reoperation rates between patients who underwent grooveplasty (proximal trochleoplasty) and patients who underwent trochleoplasty as part of a combined patellofemoral stabilization procedure. **Methods:** A retrospective chart review was performed to identify a cohort of patients who underwent grooveplasty and a cohort who underwent trochleoplasty at the time of patellar stabilization. Complications, reoperations, and PRO scores (Tegner, Kujala, and International Knee Documentation Committee scores) were collected at final follow-up. The Kruskal-Wallis test and Fisher exact test were performed when appropriate, and $P < .05$ was considered significant. **Results:** Overall, 17 grooveplasty patients (18 knees) and 15 trochleoplasty patients (15 knees) were included. Seventy-nine percent of patients were female, and the average follow-up period was 3.9 years. The mean age at first dislocation was 11.8 years overall; most patients (65%) had more than 10 lifetime instability events and 76% of patients underwent prior knee-stabilizing procedures. Trochlear dysplasia (Dejour classification) was similar between cohorts. Patients who underwent grooveplasty had a higher activity level ($P = .007$) and a higher degree of patellar facet chondromalacia ($P = .008$) at baseline. At final follow-up, no patients had recurrent symptomatic instability after grooveplasty compared with 5 patients in the trochleoplasty cohort ($P = .013$). There were no differences in postoperative International Knee Documentation Committee scores ($P = .870$), Kujala scores ($P = .059$), or Tegner scores ($P = .052$). Additionally, there were no differences in complication rates (17% in grooveplasty cohort vs 13% in trochleoplasty cohort, $P > .999$) or reoperation rates (22% vs 13%, $P = .665$). **Conclusions:** Proximal trochlear reshaping and removal of the supratrochlear spur (grooveplasty) in patients with severe trochlear dysplasia may offer an alternative strategy to complete trochleoplasty for the treatment of trochlear dysplasia in complex cases of patellofemoral instability. Grooveplasty patients showed less recurrent instability and similar PROs and reoperation rates compared with trochleoplasty patients. **Level of Evidence:** Level III, retrospective comparative study.

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Patellar instability is a common orthopaedic injury, with an annual incidence of 23.2 per 100,000 person-years, occurring most commonly among adolescents aged 14 to 18 years.[1] Recurrence rates after primary dislocation have been cited to be approximately 33%, and recurrence occurs at an average of 3 years after the index instability event.[2,3] Recurrent dislocation increases the odds of subsequent instability episodes.[2,4] Multiple anatomic factors have been linked to dislocation risk, including young age, patella alta, tibial tubercle lateralization, and trochlear dysplasia.[5] As such, patellofemoral instability can become a chronic, debilitating condition in a subset of patients and represents a complex, multifactorial problem. Although evaluation of the broad spectrum of pathoanatomic risk factors for recurrence is important in the clinical management of patellar instability, trochlear dysplasia, in particular, has been identified as a key and fundamental etiologic driver of instability.[6-8] Despite overall successful outcomes of patellar stabilization surgery, substantial controversy exists regarding the addition of à la carte trochleoplasty to other procedures such as medial patellofemoral ligament (MPFL) reconstruction.[6,7,9,10]

There are 4 described grades of trochlear dysplasia per the Dejour classification, with a supratrochlear spur on true lateral radiographs being among the defining features of grade B and D dysplasia.[10] Trochleoplasty has historically been indicated in cases of objective patellar instability associated with high-grade (grade B or D) dysplasia or recurrent instability after previous surgery.[10] Several trochlear deepening techniques have been described,[11-15] with Duncan et al.[16] succinctly summarizing many of them. Evidence has shown efficacy in correcting the underlying dysplasia and preventing instability recurrence[17]; however, trochleoplasty is often considered a highly specialized procedure that can be technically difficult. In 1988, Peterson et al.[18] described an alternative technique to reconstruct the convexity of the proximal trochlea while maintaining the native distal groove, thereby minimizing some of the technical and anatomic concerns of traditional trochleoplasty. They later termed this procedure "proximal trochleoplasty," or "grooveplasty." This technique lies at the minimally invasive end of the trochleoplasty spectrum and is, to our knowledge, one of few techniques resulting in the improvement of supratrochlear patellar engagement without sulcus deepening. It also does not require intact articular cartilage, in contrast to the trochleoplasty procedure.

Despite the numerous published studies on individual techniques, there is no clear superior trochleoplasty technique.[19] The purpose of this study was to compare the clinical efficacy in the resolution of patellar instability, patient-reported outcomes (PROs), and complication and reoperation rates between patients who underwent grooveplasty (proximal trochleoplasty) and patients who underwent trochleoplasty as part of a combined patellofemoral stabilization procedure. We hypothesized that patients would achieve similar satisfactory outcomes with grooveplasty compared with trochleoplasty but that grooveplasty patients would have less severe underlying dysplasia.

Methods

Institutional review board approval was obtained (No. 15-000601), and an established operative note database was searched for patients who underwent trochleoplasty and grooveplasty from May 2014 to November 2021. The search terms included "trochleoplasty," "grooveplasty," and "proximal trochleoplasty." Patient charts were reviewed for confirmation of the indicated procedure. Patients were included if they underwent trochleoplasty or grooveplasty for patellofemoral instability. Patients were excluded if the procedure was performed for any indication other than patellofemoral instability or trochlear dysplasia.

The most commonly applied indications for grooveplasty and trochleoplasty included persistent patellar instability refractory to conservative treatment in patients with Dejour grade B or D trochlear dysplasia, a large supratrochlear spur measuring greater than 5 to 7 mm, and a positive jumping J-sign. On the basis of our experience, grooveplasty is favored if removal of the spur alone will allow the trochlear groove to be flush with the anterior cortex of the femur. In cases in which this cannot be accomplished, trochleoplasty is preferred. In addition, in cases in which there are cartilage defects, grooveplasty is preferred. There were no cases of intraoperative conversion from one procedure to another.

Patient characteristics collected included age at the time of surgery, sex, body mass index, tobacco use, hypermobility, previous knee surgery, and other medical history. Injury characteristics and physical examination measures were also obtained. The trochlear dysplasia classification was recorded based on true lateral radiographs by an institutional fellowship–trained surgeon (A.J.K.) using the Dejour criteria.[7] All patients underwent clinical follow-up by the operating surgeon. Complications were defined as those complications related to surgery, such as arthrofibrosis and surgical-site infection; recurrent instability and persistent patellofemoral pain were reported separately.

PRO scores were collected over the phone or by email survey. These included the subjective International Knee Documentation Committee (IKDC) score, Tegner

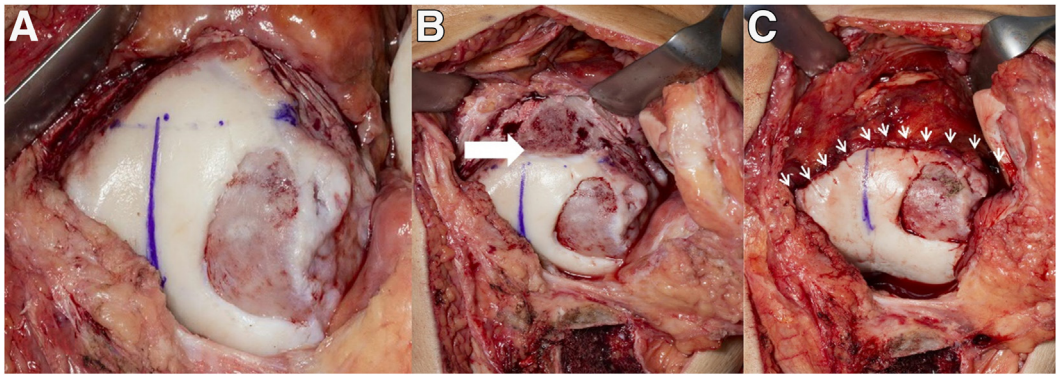

Fig 1. Grooveplasty technique in left knee. (A) View of trochlea showing supratrochlear spur, center of trochlear groove marked with sterile pen, and lateral trochlea with large chondral injury. (B) Elevation and retraction of synovium with grooveplasty to reshape trochlear groove entry (arrow). (C) Final view after suturing of synovium (white arrowheads).

score, and Kujala score. Additionally, patients were asked whether they had a recurrent instability event, defined as any dislocation or subluxation, since their last clinic follow-up, in addition to complications outside our institution's medical record.

Grooveplasty Surgical Technique

The grooveplasty technique was originally described by Peterson et al.[18,20] The primary goal is to reshape the proximal trochlear groove entry only, without changing the patellar facet height. It is important to note that grooveplasty chisels both the cartilaginous and osseous parts of the distal femoral surface, the effects of which remain unknown. Trochleoplasty, on the other hand, preserves osteochondral flaps for refixation, although this procedure is contraindicated in patients with advanced patellofemoral arthritis at baseline.

Grooveplasty is performed at the time of concomitant patellofemoral stabilization procedures including MPFL reconstruction, tibial tubercle osteotomy (TTO), femoral osteotomy, lateral lengthening, and cartilage restoration or, commonly, a combination of these procedures. The proximal trochlea is exposed through a parapatellar arthrotomy, and the center of the trochlear groove is identified. The dysplastic aspect of the proximal trochlea is reshaped by removal of the proximal trochlear cartilage followed by smoothing of the proximal trochlear groove with a burr. After completion of the grooveplasty, the surrounding synovium is anchored back to the articular cartilage margin, either with suture anchors or suture, creating a groove and facilitating appropriate patellofemoral tracking (Figs 1 and 2).

Trochleoplasty Surgical Technique

Trochleoplasty options include (1) lateral facet elevation, (2) sulcus deepening, and (3) recession wedge. Deepening and recession wedge trochleoplasties are the most performed options; however, the Dejour technique is described herein for the purposes of this study.[12] This is a sulcus deepening technique that aims to anatomically correct the underlying trochlear dysplasia.

The patella is retracted laterally, and the trochlea is exposed. A new trochlear groove is marked with a sterile pen, including the medial and lateral facet limits and a vertical line angled 3° to 6° laterally. A uniform osteochondral flap is created using an offset guide—equipped drill. Cancellous bone is then removed from the trochlear undersurface to model a new groove. The bone-cartilage flaps are then fixed down with suture tape and anchors, and the periosteum and synovial tissue are sutured to the osteochondral edge. Notably, a smaller bump height may be a limiting factor in performing trochleoplasty, especially with the use of a guided system.

Rehabilitation

All patients underwent the standard-of-care rehabilitation protocol after either grooveplasty or trochleoplasty. Postoperative care was directed by the concomitant procedures performed because the addition of a grooveplasty or trochleoplasty did not significantly alter rehabilitation. Patients were allowed full range of motion as tolerated with a typical period of protected weight bearing of 4 to 6 weeks.

Statistical Analysis

Data were stored in Microsoft Excel 2010 (Microsoft, Redmond, WA), and analysis was performed using BlueSky software (version 7.4; BlueSky Statistics, Chicago, IL). The Shapiro-Wilk test was performed to assess non-normal distributions in continuous variables, and the Kruskal-Wallis test or 1-way analysis of variance was performed accordingly. The Fisher exact test or χ^2 analysis was performed for categorical variables when appropriate. $P < .05$ was considered significant. Data are presented as number (percentage), mean (standard deviation), or median (interquartile range) where appropriate.

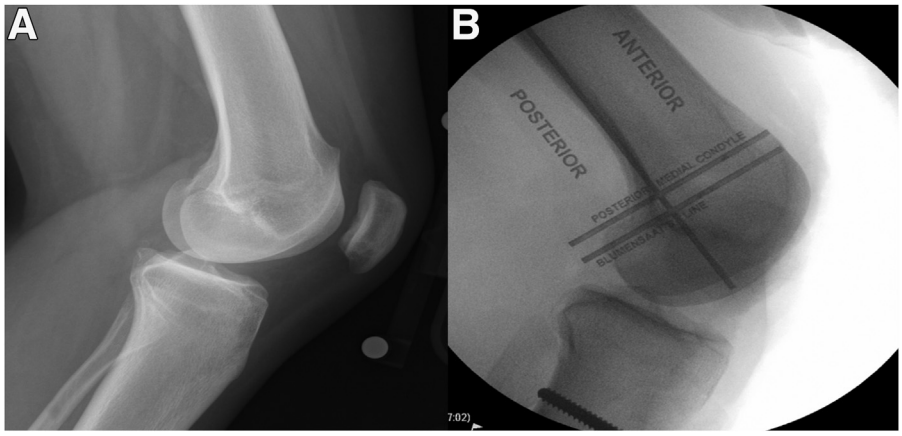

Fig 2. (A) Severe type of trochlear dysplasia with supratrochlear spur in left knee preoperatively. (B) Intraoperative imaging showing spur removal after open proximal trochleoplasty (grooveplasty) in left knee.

Results

The initial search resulted in 35 unique patients. Review of operative notes indicated that 2 patients did not undergo trochleoplasty and 1 patient underwent the procedure after persistent femur nonunion; these patients were subsequently excluded. The final cohort included 17 grooveplasty patients (18 knees) and 15 trochleoplasty patients (15 knees). Overall, most patients (79%) were female, and the mean age at the initial instability event was 11.8 years (range, 5-22 years). Most patients (65%) had more than 10 lifetime instability events. Patients underwent a grooveplasty or trochleoplasty procedure at a mean age of 21.3 years. Demographic variables were statistically similar between cohorts except hypermobility and the activity level. Four trochleoplasty patients had documented hypermobility compared with no patients in the grooveplasty cohort ($P = .033$). Additionally, trochleoplasty patients reported a lower activity level at baseline ($P = .007$). Further demographic comparisons are shown in Table 1.

All patients had severe trochlear dysplasia (Dejour grade B or D) with no significant differences in the dysplasia distribution between the 2 cohorts. Grade B dysplasia occurred in 61% of grooveplasty cases compared with 53% of trochleoplasty cases; grade D dysplasia was observed in 39% of grooveplasty cases compared with 47% of trochleoplasty cases ($P = .733$). Most patients (76%) underwent at least 1 prior patellofemoral stabilization operation, and the time from the initial instability event to either the primary grooveplasty or trochleoplasty procedure was 9.1 years overall. Grooveplasty patients had higher patellofemoral International Cartilage Research Society grades ($P = .008$), more frequently had osteochondral loose bodies ($P = .012$), and more often underwent a concomitant patellofemoral cartilage restoration procedure ($P = .027$) or TTO ($P = .005$). Cartilage restoration procedures included osteochondral autograft transplant, osteochondral allograft transplant, autologous chondrocyte implantation, patellar chondroplasty, and loose body removal. Of the 14 patients who underwent grooveplasty with concomitant TTO, 5 (36%) underwent anteriorization and medialization as opposed to pure medialization, as compared with 2 of 4 patients (50%) in the trochleoplasty cohort ($P > .99$). A complete breakdown of injury characteristics, findings on presentation, and concomitant procedures is presented in Table 2.

At final follow-up, no patients had recurrent symptomatic instability after grooveplasty compared with 5 patients in the trochleoplasty cohort ($P = .013$). In 4 of these patients, true dislocation events occurred, whereas 1 patient had chronic, symptomatic subluxation. There were no differences in subjective IKDC scores ($P = .870$), Kujala scores ($P = .059$), or Tegner activity scores ($P = .052$) between treatment groups. Additionally, there were no differences in complication rates (16.7% in grooveplasty cohort vs 13.3% in trochleoplasty cohort, $P > .999$) or reoperation rates (22.2% vs 13.3%, $P = .665$) at a mean follow-up of 47.1 months (range, 5.6-94.4 months) (Table 3).

Discussion

The principal findings of this study were as follows: None of the grooveplasty patients had recurrent instability compared with one-third of patients in the trochleoplasty cohort, with similar complication rates (16.7% vs 13.3%, $P > .999$) and reoperation rates (22.2% vs 13.3%, $P = .665$) between the groups. However, it is important to highlight that only 27% of the trochleoplasty patients underwent TTO compared with 78% in the grooveplasty cohort, although these groups were comparable in type of TTO performed (anteriorization and medialization vs pure medialization). Additionally, higher Kujala and Tegner scores were noted in the grooveplasty cohort, although these did not reach the level of statistical significance (82.0 vs

Table 1. Comparison of Baseline Demographic Characteristics Between Grooveplasty and Trochleoplasty Cohorts

	Overall (N = 33)	Grooveplasty (n = 18)	Trochleoplasty (n = 15)	*P* Value
Age at initial instability event, mean (range), yr	11.8 (5-22)	11.3 (5-15)	12.3 (7-22)	.469
Age at surgery, mean (range), yr	21.3 (14-39)	21.1 (14-39)	21.5 (15-36)	.860
Sex				.413
Male	7 (21.2)	5 (27.8)	2 (13.3)	
Female	26 (78.8)	13 (72.2)	13 (86.7)	
Laterality				.722
Left	20 (60.6)	10 (55.6)	10 (66.7)	
Right	13 (39.4)	8 (44.4)	5 (33.3)	
BMI, mean (SD)	27.8 (7.4)	28.0 (5.6)	27.6 (9.3)	.885
Hypermobility	4 (12.1)	0 (0.0)	4 (26.7)	.033*
Occupation				.160
Student	24 (72.7)	14 (77.8)	10 (66.7)	
Laborer	6 (18.2)	4 (22.2)	2 (13.3)	
Sedentary	3 (9.1)	0 (0.0)	3 (20.0)	
Activity level				.007*
Sedentary	4 (13.8)	0 (0.0)	4 (28.6)	
Recreational	16 (55.2)	7 (46.7)	9 (64.3)	
Competitive	9 (31.0)	8 (53.3)	1 (7.1)	
Other or not reported	4	3	1	
Lifetime instability events				.118
<5	6 (19.4)	3 (16.7)	3 (23.1)	
5-10	5 (16.1)	5 (27.8)	0 (0.0)	
>10	20 (64.5)	10 (55.6)	10 (76.9)	
NA	2	0	2	
Prior patellar stabilization procedures	25 (75.8)	13 (72.2)	12 (80.0)	.699

NOTE. Data are presented as number (percentage) unless otherwise indicated.
BMI, body mass index; NA, not available; SD, standard deviation.
*Statistically significant ($P < .05$).

69.0 [$P = .059$] and 6.0 vs 4.0 [$P = .052$], respectively). Ultimately, persistent patellofemoral pain occurred in both groups, with 44.4% of grooveplasty patients and 20.0% of trochleoplasty patients having documented patellofemoral arthritis.

Trochlear dysplasia exists on a spectrum, resulting in an array of surgical options from minimally invasive arthroscopic bumpectomy[21] to various methods of trochleoplasty.[10,12-15,22] For patients with grade B and D trochlear dysplasia with a supratrochlear spur, evidence has shown that sulcus deepening trochleoplasty can improve patellofemoral stability,[17,23] although patients tend to also have congruent dysplasia that likewise affects the patella.[24] At a mean of 15 years' follow-up, Rouanet et al.[17] reported no recurrent objective instability episodes in 34 patients who underwent sulcus deepening trochleoplasty, with better functional outcomes in those with a preoperative supratrochlear spur than in those without a spur. A 2017 systematic review and meta-analysis concluded that patients who underwent trochleoplasty plus an extensor balancing procedure had a 2.1% rate of redislocation and/or subluxation compared with 7% in patients who underwent MPFL reconstruction alone.[25] In our study, concomitant MPFL reconstruction or revision reconstruction was performed in 94% of grooveplasty cases and 80% of trochleoplasty cases, demonstrating the essential role of this structure in the success of stabilization. This study reports a slightly higher rate of recurrence of instability after trochleoplasty (5 of 15, or 33%) compared with the contemporary literature. Certainly, the added complexity of hypermobility or congenital disease at baseline can be posited as a contributing factor, in addition to the fact that one-third of the trochleoplasty patients underwent TTO compared with three-quarters of the grooveplasty patients. One possibility is that there is some degree of "at risk" patient for instability recurrence that was difficult to objectively quantify, and these complex, high risk patients were selected by surgeons to undergo trochleoplasty. It is interesting to note that other demographic and injury characteristics were comparable between the trochleoplasty and grooveplasty cohorts, with no recurrent instability events reported after grooveplasty at a mean follow-up of 3.56 years. Finally, 76% of patients had undergone at least 1 prior intervention that failed to resolve instability, reflecting the complex nature of this unique subset of instability patients. Although the sample size is small, these preliminary results suggest that grooveplasty may offer an effective alternative strategy to trochleoplasty for the treatment of severe trochlear dysplasia with a supratrochlear spur.

Although there were no significant differences in PRO scores, the Tegner and Kujala scores trended toward significance with better outcomes in the grooveplasty

Table 2. Comparison of Injury Characteristics Between Cohorts

	Overall (N = 33)	Grooveplasty (n = 18)	Trochleoplasty (n = 15)	*P* Value
Trochlear dysplasia grade (Dejour classification)				.733
A	0 (0.0)	0 (0.0)	0 (0.0)	
B	19 (57.6)	11 (61.1)	8 (53.3)	
C	0 (0.0)	0 (0.0)	0 (0.0)	
D	14 (42.4)	7 (38.9)	7 (46.7)	
Flexion at patellar reduction, mean (SD), °	37.0 (11.6)	38.0 (4.5)	36.5 (14.2)	.824
Valgus alignment	15 (45.5)	9 (50.0)	6 (40.0)	.446
Patella alta	15 (45.5)	8 (44.4)	7 (46.7)	>.999
Femoral anteversion	4 (12.1)	2 (11.1)	2 (13.3)	>.999
TT-TG distance, mean (SD), mm	17.6 (4.1)	19.3 (3.5)	15.7 (4.1)	.016*
ICRS grade				.008*
0	0 (0.0)	0 (0.0)	0 (0.0)	
1	2 (6.1)	0 (0.0)	2 (13.3)	
2	12 (36.4)	4 (22.2)	8 (53.3)	
3	5 (15.2)	2 (11.1)	3 (20.0)	
4	11 (33.3)	10 (55.6)	1 (6.7)	
NA	3 (9.1)	2 (11.1)	1 (6.7)	
Osteochondral loose body	12 (37.5)	10 (58.8)	2 (13.3)	.012*
Concomitant procedure	31 of 33 (93.9)	18 of 18 (100)	13 of 15 (86.7)	.478
None	2 (6.1)	0 (0.0)	2 (13.3)	—
MPFL	29 (87.9)	17 (94.4)	12 (80.0)	.308
TTO	18 (54.5)	14 (77.8)	4 (26.7)	.005*
Femoral osteotomy	7 (21.2)	6 (33.3)	1 (6.7)	.095
Cartilage restoration	12 (36.4)	10 (55.6)	2 (13.3)	.027*
Lateral retinacular lengthening	24 (73.7)	12 (66.7)	12 (80.0)	.458

NOTE. Data are presented as number (percentage) unless otherwise indicated.

ICRS, International Cartilage Research Society; MPFL, medial patellofemoral ligament; NA, not available; SD, standard deviation; TT-TG, tibial tubercle—trochlear groove; TTO, tibial tubercle osteotomy.

*Statistically significant ($P < .05$).

cohort. It is important to note that surgeon selection for the addition of trochleoplasty in patients with more severe disease, as well as a lower baseline activity level in trochleoplasty patients, likely contributed to the differences in Tegner scores. Mengis et al.[26] have previously shown that athletes with low levels of activity (Tegner scores of 0-4) are able to participate at a higher level of sports activity after trochleoplasty, whereas higher-level athletes (Tegner scores of 5-10) return to a lower level. Grooveplasty patients in our study participated in recreational and competitive activity more frequently than trochleoplasty patients at baseline, but in contrast to the results of Mengis et al., we found that grooveplasty patients reported a median Tegner score of 6 at short-term follow-up, implying that grooveplasty may have at least a similar, if not improved, effect on the return to activity in the right setting. In a study of 67 prospectively enrolled knees with severe trochlear dysplasia, Carstensen et al.[27] reported significant improvements in IKDC scores and Kujala scores, as well as high satisfaction rates, after trochleoplasty. Similarly, Zimmermann et al.[28] showed that deepening trochleoplasty improved Kujala scores from 55 preoperatively to 82.5 postoperatively while decreasing the intensity of patellofemoral pain at both 12 and 24 months. Although not significant in our cohort, grooveplasty patients had a median Kujala score of 82 at final follow-up compared with 69 in trochleoplasty patients while maintaining a similar complication and reoperation profile.

The pathoanatomy of patellar maltracking is itself a risk factor for patellofemoral cartilage degeneration, pain, and eventual osteoarthritis (OA).[29] This risk must be weighed against the unclear possibility of OA development due to burring or subchondral bone removal during trochleoplasty. In the study of Rouanet et al.,[17] 10 of 34 patients had preoperative OA with an Iwano grade of less than 2. At 15 years of follow-up after trochleoplasty, the number increased to 33 of 34 patients, with 65% progressing to an Iwano grade greater than 2 and with 7 patients requiring total knee arthroplasty. Conversely, other studies have shown a minimal direct effect of trochleoplasty on cartilage damage and the risk of significant patellofemoral arthritis.[30-32] Grooveplasty offers the ability to address the problematic supratrochlear spur while maintaining subchondral bone integrity in cases in which a cartilage restoration procedure is likely indicated. In our study, pre-existing patellofemoral chondrosis was reported in three-quarters of grooveplasty patients and two-thirds of trochleoplasty patients. This finding is in parallel with the available evidence and lends further credence to the idea that the ideal trochleoplasty patient is young, with minimal chondral damage and good

Table 3. Outcomes

	Grooveplasty (n = 18)	Trochleoplasty (n = 15)	*P* Value
Mean follow-up (range), mo	50.8 (6.1-94.4)	42.7 (5.6-80.6)	.423
Mean arc of motion	131.7	125.5	.134
Recurrent instability	0 (0.0)	5 (33.3)	.013*
Persistent patellofemoral pain	5 (27.8)	2 (13.3)	.413
Patellofemoral chondrosis	8 of 18 (44.4)	3 of 15 (20.0)	.266
Chondrosis prior to procedure	6 (75)	2 (66.7)	
Complications	3 (16.7)	2 (13.3)	>.999
Wound infection	1 (5.6)	0 (0.0)	
Arthrofibrosis	2 (11.1)	2 (13.3)	
Reoperations	4 (22.2)	2 (13.3)	.665
MUA and/or LOA	2 (11.1)	2 (13.3)	
Wound irrigation	1 (5.6)	0 (0.0)	
Trochlear chondroplasty	1 (5.6)	0 (0.0)	
Tibial osteotomy	1 (5.6)	0 (0.0)	
PRO, median (IQR)			
Kujala score	82.0 (74.5, 91.0)	69.0 (63.5, 82.0)	.059
Tegner score	6.0 (4.0. 6.5)	4.0 (3.0, 5.0)	.052
Subjective IKDC score	70.1 (58.1, 81.6)	59.2 (55.2, 82.2)	.870

NOTE. Data are presented as number (percentage) unless otherwise indicated.

IKDC, International Knee Documentation Committee; IQR, interquartile range; LOA, lysis of adhesions; MUA, manipulation under anesthesia; PRO, patient-reported outcome.

*Statistically significant ($P < .05$).

healing potential.[31,33-35] Earlier intervention in these patients is believed to minimize prolonged overloading of the patellofemoral joint and potentially lead to better outcomes.[35] Of note, our grooveplasty patients had significantly higher International Cartilage Research Society grades, more frequently had osteochondral loose bodies, and more often required a concomitant cartilage restoration procedure and/or TTO compared with trochleoplasty patients. It remains uncertain whether earlier trochlear intervention is indicated à la carte in select cases of severe dysplasia and complex instability; however, it is important to recognize that in this study, the mean time from the initial instability event to the grooveplasty and trochleoplasty interventions was 7.9 years and 10.4 years, respectively.

Finally, trochleoplasty is a substantial surgical intervention, requiring thorough planning, careful patient selection, and a high degree of surgical skill. Various complications include worsened patellofemoral pain, range-of-motion deficit, stiffness, and failure to resolve instability. Furthermore, the risk of overcorrection or undercorrection and iatrogenic cartilage damage remains.[35] Despite these considerations, trochleoplasty has been shown to yield good patient satisfaction and a low risk of significant complications.[27,36,37] Our study shows acceptable complication (13%) and reoperation (13%) rates after trochleoplasty; however, perhaps a simpler grooveplasty procedure may be adequate in achieving similar outcomes.

Limitations

There are several limitations to this study that merit discussion. The nonrandomized design of this study introduces the likely presence of selection bias, and the retrospective nature has inherent information limitations. One central example of this is the degree to which existing patellofemoral chondrosis at the time of comprehensive surgical correction influences surgeon decision making regarding one procedure over another. In addition, the heterogeneity of concomitant procedures, specifically in terms of MPFL reconstruction or TTO, makes it difficult to define the success of either trochleoplasty or grooveplasty alone, although it is worth mentioning that these techniques are rarely performed without concomitant procedures. Furthermore, there is limited ability to objectively assess patients at risk of instability recurrence, and the question remains as to whether higher-risk patients received trochleoplasty and lower-risk patients received grooveplasty, artificially making grooveplasty appear superior. Additionally, these patients represent a subset of complex patellofemoral instability cases, and thus, some were referred to our academic institution for specialized care. The level of surgeon expertise required to perform trochleoplasty or grooveplasty may limit the generalizability of these results. Finally, this study was underpowered, and the small sample size limited our ability to perform subgroup analyses.

Conclusions

Proximal trochlear reshaping and removal of the supratrochlear spur (grooveplasty) in patients with severe trochlear dysplasia may offer an alternative strategy to complete trochleoplasty for the treatment of trochlear dysplasia in complex cases of patellofemoral

instability. Grooveplasty patients showed less recurrent instability and similar PROs and reoperation rates compared with trochleoplasty patients.

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