Outcomes After Deepening Trochleoplasty and Concomitant Realignment in Patients With Severe Trochlear Dysplasia With Chronic Patellofemoral Pain

Results at 2-Year Follow-up

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Background: Abnormal patellofemoral joint stress appears to have major relevance in a subgroup of patients with patellofemoral pain (PFP).

Purpose: To evaluate whether patients with chronic PFP and trochlear dysplasia–induced patellofemoral joint malalignment benefit from a deepening trochleoplasty procedure with the aim of improving patellotrochlear congruence.

Study Design: Case series; Level of evidence, 4.

Methods: Included were 15 patients (male/female, 1/14; mean age, 30.3 years [range, 19-51 years]) with 8.8 years (range, 1-20 years) of chronic PFP and severe trochlear dysplasia. All patients underwent correction of patellotrochlear malalignment with deepening trochleoplasty and concomitant realignment procedures. The Kujala score and a numerical analog scale (0-10) for intensity of pain were used to assess symptoms preoperatively and at 12 and 24 months postoperatively. Pre- and postoperative magnetic resonance imaging (MRI) scans from the patients were compared with the MRI scans of age- and sex-matched controls regarding the patellotrochlear contact area and contact ratio, patellar tilt, patellotrochlear index, and lateral trochlear inclination (LTI) angle.

Results: The Kujala score increased from a mean of 55 (range, 15-81) preoperatively to 82.5 (range, 53-98) after 12 months (95% CI, –42.56 to –12.37; $P < .001$) and to 84.2 (range, 59-99) after 24 months (95% CI, –44.29 to –14.11; $P < .001$). The intensity of PFP decreased from 5.7 (range, 3-10) preoperatively to 1.4 (range, 0-4) after 12 months (95% CI, 2.57 to 5.96; $P < .001$) and had a mean of 1.6 (range, 0-6) after 24 months (95% CI, 2.44 to 5.75; $P < .001$). Preoperatively, parameters in the study group indicated significant patellotrochlear malalignment, which improved and normalized (except for the LTI angle) postoperatively compared with the values of the control group ($P > .05$).

Conclusion: In a subgroup of patients with chronic PFP due to severe trochlear dysplasia, deepening trochleoplasty and concomitant realignment procedures significantly reduced pain and improved knee joint function while normalizing patellotrochlear congruence.

Keywords: patellofemoral pain; patellofemoral malalignment; trochlear dysplasia; trochleoplasty

With an incidence of 22 per 1000 persons per year and a prevalence of 3% to 40%, patellofemoral pain (PFP) is a common musculoskeletal disorder, particularly affecting females during adolescence.[9,11,16,40] Numerous etiological factors (anatomic, biomechanical, social, psychological, etc) have been described and were recently incorporated into a pathomechanical model based on the assumption that PFP is associated with an abnormal patellofemoral joint (PFJ) load.[41] According to Crossley et al,[18] *patellofemoral pain* is the preferred term and is used as a synonym for *PFP syndrome*, *chondromalacia patella*, and *anterior knee pain*.

Recent studies suggest that chronic PFP may predispose patients to patellofemoral osteoarthritis (PFOA).[20,23,47] One probable association likely linking PFP and PFOA is PFJ malalignment, which leads to alterations in PFJ biomechanics.[15,23] In this regard, a clear correlation between trochlear dysplasia and cartilage lesions within the PFJ has been identified.[30,31,37] In addition, a recent systematic

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review found strong evidence that PFOA is associated with both frontal plane knee alignment and trochlear dysplasia.[36] In particular, severe dysplastic trochlea (type B/D according to Dejour) decreases the PFJ contact area and increases cartilage wear through peak contact pressure.[51]

Correction of trochlear dysplasia with deepening trochleoplasty has become an established operative procedure to treat lateral patellar dislocations for patients in whom severe dysplastic trochlea was identified as the most relevant factor of patellar instability.[3] Although PFP is a different clinical entity, it shows overlapping characteristics with lateral patellar instability. In this regard, trochlear dysplasia is likely to have major relevance by inducing an abnormal PFJ stress in a subgroup of patients with PFP. A previous study of patients with recurrent patellar instability[4] demonstrated that the trochleoplasty procedure could normalize patellotrochlear congruence; in particular, the procedure increased the patellotrochlear contact area and contact ratio.[4] Based on these previous findings, operative restoration of patellotrochlear congruence may be beneficial for patients experiencing chronic trochlear dysplasia-induced PFP; however, until recently, trochleoplasty surgery was reserved for the treatment of patellar instability. Therefore, the aim of this study was to evaluate whether patients with chronic PFP and trochlear dysplasia-induced PFJ malalignment would benefit from a deepening trochleoplasty procedure. The hypothesis was that improvements in the patellotrochlear alignment parameters could result in reduced pain and recovered knee joint function in patients with trochlear dysplasia-induced chronic PFP.

METHODS

Study Design and Study Group

This was a retrospective analysis of a longitudinally maintained database. Approval for this study was granted by the local ethics committee. Between April 2015 and August 2019, 522 patients were initially evaluated at our outpatient clinic because of PFP. After a thorough clinical and radiographic evaluation (see the sections below), patients diagnosed with PFJ malalignment due to severe trochlear dysplasia, which is interpreted as the major cause of PFP (inclusion criterion), were included (n = 23). The exclusion criterion was PFP due to reasons other than severe trochlear dysplasia. The first 15 patients (male/female, 1/14; mean age, 30.3 years [range, 19-51 years]) underwent surgery performed by the senior author (P.B.) between July 2016 and September 2018 and completed the 2-year follow-up, thus constituting the study group for this investigation. Among these 15 participants, no patient was excluded, and no patient was lost to follow-up within the 2-year period. In addition, postoperative magnetic resonance imaging (MRI) investigation was available in 12 of those patients.

The included patients had experienced PFP for a mean of 8.8 years (range, 1-20 years) with failed nonoperative treatment. In addition, 7 patients had undergone a previous surgery, including tibial tubercle transfer (n = 4), medial retinacular reefing (n = 2), lateral release (n = 2), medial patellofemoral ligament (MPFL) reconstruction (n = 2), and autologous chondrocyte transplantation at the patella (n = 2). Before trochleoplasty surgery, all nonoperative and operative treatment options were discussed, and patients were informed that deepening trochleoplasty is an established treatment for patellar instability but has not yet been established for the treatment of PFP. Each patient signed an informed consent form before the operation.

All patients were treated with a deepening trochleoplasty using an open procedure according to von Knoch et al[33] in combination with lengthening of the lateral retinaculum to correct severe trochlear dysplasia-induced PFJ malalignment (Figure 1 and Table 1).

Inclusion criteria for performing the trochleoplasty procedure were trochlear dysplasia type B or D on transverse MRI images, a lateral trochlear inclination (LTI) angle $<12^{\circ}$, and a clinical J sign of grade II or III.[46] Preoperatively, 6 patients had type B trochlear dysplasia, and 9 patients had type D trochlear dysplasia according to the Dejour criteria.[21] Additional procedures included MPFL reconstruction (n = 3), medial retinacular reefing (n = 4), and tibial tubercle (TT) osteotomy (TTO) (n = 6) with TT anteromedialization (AMZ) in 4 patients, TT distalization in 1 patient, and combined TT AMZ and distalization in 1 patient. Concomitant TTO was considered when the tibial tuberosity–trochlear groove (TT-TG) distance exceeded 20 mm, when the tibial tuberosity–posterior cruciate ligament (TT-PCL) distance exceeded 24 mm, and/or when the Caton-Deschamps index was ≥ 1.4. Concomitant MPFL reconstruction or medial reefing was considered in cases of medial retinacular structure insufficiency due to chronic patellar lateralization. None of the patients reported gross patellar dislocation.

Mobilization was initiated on the second day after the operation with active and passive exercises, including continuous passive motion as tolerated. Partial weightbearing was recommended for 3 weeks with transition to full weightbearing afterward as tolerated. Patients

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Ethical approval for this study was obtained from the Ethics Committee of Baden-Württemberg, Germany (F-2019-070).

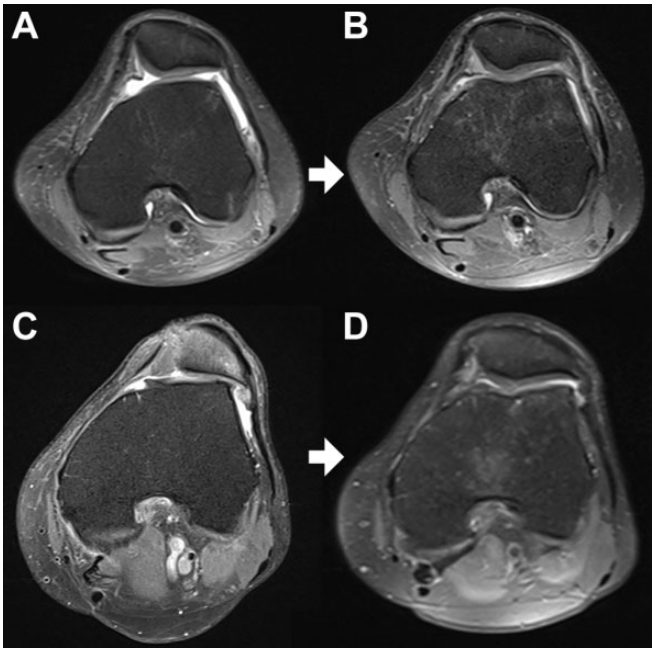

Figure 1. (A) Pre- and (B) postoperative transverse magnetic resonance imaging (MRI) scans obtained from a 30-year-old female patient 12 months after deepening trochleoplasty. In this patient, the Kujala score increased from 61 preoperatively to 94 after 2 years of follow-up. Before the operation, the patient was treated for patellofemoral pain (PFP) for 4 years. (C) Pre- and (D) postoperative MRI scans obtained from a 40-year-old female patient 9 months after deepening trochleoplasty. The Kujala score increased from 67 preoperatively to 92 after 2 years of follow-up. Before the operation, the patient was treated for PFP for 15 years. Note the reshaped trochlear groove with an increased patellotrochlear contact area and the reduced lateral patellar tilt angle in both patients.

underwent physical therapy for a total of 3 months postoperatively.

Physical Examination

The following physical examinations were performed for the study group: evaluations of the long axis of the leg in both standing and supine positions; examinations for knee joint effusion, capsular swelling, and tenderness along the medial and lateral retinacular structures and along the quadriceps or patellar tendon; measurements of the knee joint range of motion; patellar glide tests; patellar apprehension tests at 30° of knee joint flexion; evaluations of the J sign; and assessments of patellofemoral crepitus and patellar locking or snapping during active and passive knee joint movements. Both 2-leg and 1-leg squats were used to visualize dynamic valgus malalignment (balance, trunk posture, pelvis posture, hip adduction, and knee valgus were assessed), and the patients were also screened for femoral and tibial torsional deformities and foot disorders or deformities, such as increased rear-foot eversion or pes pronatus valgus.[2]

Patient-Reported Outcome Measures

Regarding clinical evaluations, the Kujala anterior knee pain scale[34] was used to assess patients' symptoms before surgery and at 12 and 24 months postoperatively. In addition, a numerical analog scale (0-10) was used to assess the intensity of PFP (0 = no pain; 10 = most severe pain) preoperatively and again at 12 and 24 months postoperatively.

Radiography and MRI Investigation

Preoperative MRI data and routine radiographs (standing long-leg axis radiograph and lateral view radiograph of the knee joint) were evaluated for the severity of trochlear dysplasia using the LTI angle[38] and Dejour criteria.[21] In addition, patellar height was assessed using the Caton-Deschamps index[12] and the patellotrochlear index (PTI) according to Biedert and Albrecht.[7] The TT-TG distance,[43] TT-PCL distance,[44] and varus-valgus alignment[29] were evaluated in every patient (as published previously). In addition, our approach to describing the methods used was similar to an approach that we used previously.[4] Briefly, the patellotrochlear contact ratio was calculated as the quotient of the lengths of the patellotrochlear contact area divided by the total length of the patellar cartilaginous surface (Figure 2A). A quotient of 1.0 indicated complete cartilaginous overlap.[4] The patellotrochlear contact area was determined by measuring the length of the contact between the patella and trochlea (Figure 2B, black line) in each sagittal slice. This length was multiplied by the slice thickness (3 mm), and the results were then summed to yield the patellotrochlear contact area.[28] The lateral patellar inclination angle (patellar tilt) was measured using the line through the transverse axis of the patella and the posterior condylar axis.[21]

Postoperative MRIs were performed in 12 patients of 15 patients after a mean of 14 months (range, 9-22 months). All MRI scans were performed on a 1.5-T Imager (Avanto; Siemens) with a standard knee coil and the knee positioned in slight degrees of knee flexion (mean, 12°; range, 8°-18°) as previously recommended.[13] The measurements were obtained using open-source picture archiving and communication system workstation software (OsiriX Version 5.8.5; Pixmeo SARL).

Control Group (for Radiographic Analysis)

The control group comprised 24 age- and sex-matched patients (male/female, 2/22; mean age, 28 years [range, 18-47 years]). The patients were treated for meniscal tears during the same period. None of the patients had any medical history related to the PFJ.

Whole-Organ Magnetic Resonance Imaging Score

The preoperative PFJ status (cartilage lesion, bone marrow abnormality/edema, subchondral bone cysts, osteophytes) of the study group was determined with the PFJ subscore

TABLE 1
Characteristics, Anatomic Values, and Treatment Procedures of the Study Group[a]

Patient No.	Sex, Age (y)	Symptom Duration (y)	Trochlear Dysplasia Type[b]	TT-TG Distance, TT-PCL Distance (mm)	Patellar Height[c]	Frontal Plane Alignment[d] (deg)	BMI	PTI	Treatment
1	F, 27	7	B	12, 15	1.4	4.5	33.4	0	Trochleoplasty; LRL; partial lateral patellar facetectomy
2	F, 26	1	D	17, 23	1.4	0.5	NA	25	Trochleoplasty; LRL; MPFL reconstruction
3	F, 35	1	B	20, 22	0.8	1.6	28.4	28	Trochleoplasty; LRL; cartilage debridement
4	F, 21	6	B	17, 27	1.2	NA	23.5	12	Trochleoplasty; LRL; partial lateral patellar facetectomy; resection of osteophytes
5	F, 29	20	D	18, 22	0.7	0	19.8	48	Trochleoplasty; MPFL reconstruction; LRL; cartilage debridement
6	F, 33	20	D	19, 28	1.1	–0.5	24.0	31	Trochleoplasty; TTO-AMZ; LRL; partial lateral patellar facetectomy; retropatellar subchondral bone drilling
7	F, 34	15	D	16, 29	1.2	–3.0	26.0	41	Trochleoplasty; LRL; MPFL reconstruction; retropatellar subchondral bone drilling
8	F, 19	6	D	6, 6	1.2	–5.0	24.1	NA	Trochleoplasty; LRL; cartilage debridement
9	F, 24	1	D	8, 8	1.3	2.0	21.3	57	Trochleoplasty; LRL; medial reefing
10	F, 30	4	B/D	13, 26	1.2	–3.5	21.3	56	Trochleoplasty; LRL; TTO-AMZ; medial reefing
11	M, 30	2	D	18, 20	1.2	1.0	23.5	39	Trochleoplasty; LRL; medial reefing
12	F, 40	15	D	18, 20	1.5	–2.5	23.5	0	Trochleoplasty; LRL; TTO-distalization
13	F, 27	4	B/D	11, 22	0.9	2.0	30.5	60	Trochleoplasty; LRL; TTO-AMZ
14	F, 51	20	D	20, 25	1.3	0	21.6	33	Trochleoplasty; LRL; TTO-distalization/AMZ
15	M, 28	10	B	16, 25	1.0	0	21.3	48	Trochleoplasty; LRL; TTO-AMZ; medial reefing

[a]AMZ, anteromedialization; BMI, body mass index; F, female; LRL, lateral retinacular lengthening; M, male; MPFL, medial patellofemoral ligament; NA, not applicable; PTI, patellotrochlear index; TTO, tibial tubercle osteotomy; TT-PCL, tibial tuberosity–posterior cruciate ligament; TT-TG, tibial tuberosity–trochlear groove.
[b]Trochlear dysplasia was assessed according to the Dejour classification.
[c]Patellar height was assessed according to the Caton-Deschamps index.
[d]Positive values indicate varus alignment; negative values indicate valgus alignment.

of the Whole-Organ Magnetic Resonance Imaging Score (WORMS), according to Peterfy et al.[39] The minimum and maximum values of the subscore are 0 (normal joint status) and 88 (severe osteoarthritis), respectively.

Statistical Analysis

The data were assessed for normality using the Kolmogorov-Smirnov test and are presented as the mean (range). Paired 2-tailed *t* tests were used to assess differences between the pre- and postoperative clinical data and between the MRI measurements within the study group and those within the control group. One-way analysis of variance with Bonferroni correction was used to assess differences among all measurement series. The influence of PFJ degeneration (WORMS) on the Kujala score results was assessed by linear regression analysis. All analyses were performed using GraphPad Prism Version 4 (GraphPad Software). The level of significance was set at .05.

RESULTS

The patient characteristics and anatomic risk factors are presented in Table 1. The Kujala score increased by a mean of 29.9 points from a mean of 55 (range, 15-81) preoperatively to 82.5 (range, 53-98) after 12 months (95% CI, –42.56 to –12.37; $P < .001$) and to 84.2 (range, 59-99) at the 24-month follow-up (95% CI, –44.29 to –14.11; $P < .001$). The intensity of PFP decreased from 5.7 (range, 3-10) preoperatively to 1.4 (range, 0-4) after 12 months (95% CI, 2.57 to 5.96; $P < .001$) and was a mean of 1.6 (range, 0-6) after 24 months (95% CI, 2.44 to 5.75; $P < .001$).

The patellofemoral contact area increased from 140 mm^2 (range, 30-173 mm^2) preoperatively to 229 mm^2 (range, 128-296 mm^2) postoperatively (95% CI, –141.7 to –30.14; $P = .007$). The patellotrochlear contact ratio was a mean of 0.34 ± 0.16 (range, 0.0-0.49) preoperatively and increased to 0.58 ± 0.19 (range, 0.22-0.83) postoperatively (95% CI, –0.38 to –0.08; $P = .007$), and the patellar tilt decreased from 33 ± 14° (range, 11°-52°) to 15° ± 6° (range, 5°-23°) (95% CI, 8.88 to 26.92; $P = .0015$). Parameters normalized compared with the values of the control group: contact ratio, 0.67 ± 0.11 (range, 0.48-0.88; 95% CI, –0.208 to 0.025; $P = .11$); contact area, 189 ± 17 mm^2 (range, 167-227 mm^2; 95% CI, –0.309 to 68.73; $P = .052$); and patellar tilt, 8 ± 5° (range, 1-16°; 95% CI, –2.956 to 16.98; $P = .06$).

The LTI angle increased from 0.5° (range, –9° to 10°) preoperatively to 9.9° (range, 6°-15°) postoperatively

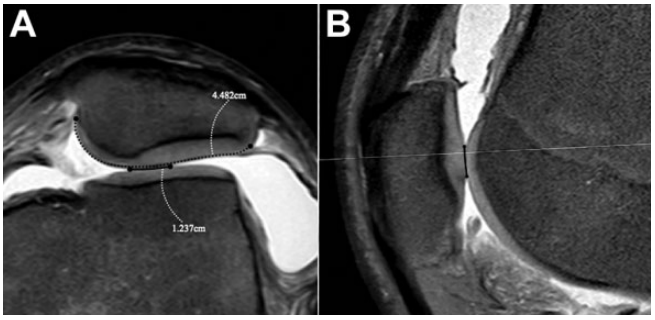

Figure 2. Evaluation of the patellotrochlear contact ratio and the patellotrochlear contact area on transverse and sagittal magnetic resonance imaging scans. From the first craniocaudal image on which trochlear cartilage was identified, (A) the next 2 caudal images were analyzed, (B) with the corresponding sagittal plane used for additional height control. (A) The patellotrochlear contact ratio was calculated by the quotient of the lengths of the patellotrochlear contact area (solid black line) divided by the total length of the patellar cartilage surface (dotted black line). (B) The contact area was assessed by measuring the length of contact between the patella and trochlea in each sagittal slice (black line).

(95% CI, –12.6 to –6.26; $P < .001$) but remained inferior compared with the control group (mean value, 16.8° [range, 2°-24°]; 95% CI, –12.12 to –1.63; $P < .01$). The PTI increased nonsignificantly from 35.8% (range, 0%-60%) preoperatively to 48.6% (range, 20%-67%) postoperatively (95% CI, –27.17 to –1.63; $P > .05$). Exclusion of PTI values of the 2 patients who underwent additional TTO distalization did not change the overall PTI results (preoperative mean, 39.4% [range, 0%-60%]; postoperative mean, 49.3% [range, 20%-67%]; 95% CI, –24.91 to 5.09; $P > .05$). In addition, the preoperative values did not differ from those of the control group (34.4% [range, 19%-54%]; 95% CI, –11.43 to 19.0; $P > .05$) (Figure 3).

Seven patients showed no changes or minor cartilage changes (WORMS; range, 0-10). In 8 patients, cartilage damage (Outerbridge grades III and IV) was observed during the operation, which was predominantly located at the lateral patellar facet and the anterolateral trochlea, where dysplasia was most prominent. The severity of preoperative PFJ arthritis (WORMS-PFJ subscore, 16.5 ± 10.5 [range, 1-34]) did not influence the overall Kujala score increase or the final Kujala score results ($r^2 = 0.06$, $P = .49$ [95% CI, –0.746 to 1.426]; $r^2 = 0.07$, $P = .47$ [95% CI, –0.733 to 1.451]). However, the statistical power values (1 – ß error probability) to determine a significant correlation between PFJ arthritis and clinical outcome were only 0.35 and 0.33, respectively, with the given sample size (G*Power Software Version 3.1.3).

DISCUSSION

The aim of this study was to evaluate whether patients with malalignment-induced PFP would benefit from bony realignment surgery. The most important findings of this study indicate that in patients with chronic PFP due to severe trochlear dysplasia, deepening trochleoplasty with concomitant realignment procedures can significantly improve the symptoms of PFP while normalizing patellotrochlear congruence.

Patellar malalignment and/or maltracking has been considered one of the major pathomechanical reasons for PFP.[41] In this regard, PFJ malalignment can be caused by active factors (ie, impaired hip and trunk muscle performance) and static factors (ie, altered bony anatomy) contributing to a diminished PFJ contact area with consecutive PFJ overload. The bony factors include excessive femur antetorsion, patella alta, frontal plane malalignment with altered tibiofemoral joint kinematics, altered foot mechanics, and trochlear dysplasia.[41]

In a biomechanical model, van Haver et al[51] showed that the elevated anterolateral femoral cortex observed in severe trochlear dysplasia results in a reduced patellofemoral contact area, increased contact pressure, and increased patellar lateralization. These findings were confirmed by the preoperative status of our study group, and our results are consistent with those of other reports documenting a significantly reduced contact area and contact ratio and an increased lateral patellar tilt in the presence of trochlear dysplasia.[4,25] The data in this study also support previously published results indicating that the reduced PFJ contact area in symptomatic persons is predominantly observed in the nearly extended (20° of flexion) knee but not during 40° of knee joint flexion.[4,6] In addition, differences in the contact area appear to diminish between patients with PFP and asymptomatic controls with higher degrees of knee joint flexion.[5,42] These findings might be explained by the embryonic development of a dysplastic trochlea, which is localized in the very proximal part of the trochlea, where the patella engages during early knee joint flexion[21] and normalizes when the patella moves deeper within the trochlear groove. Therefore, anatomic congruity in the proximal part of the PFJ appears essential and was represented by the imaging modalities used in this study.

Our data also provide some reasonable support to previous investigations in which patients with PFP exhibited a greater PFJ load during walking and squatting with low degrees of knee joint flexion,[24,27] whereas studies investigating PFJ cartilage stress with high degrees of flexion found no differences between patients and controls.[6,10] However, factors other than trochlear dysplasia (increased femoral antetorsion and femorotibial rotation, patella alta, impaired quadriceps function, contracture of lateral soft tissue restraints, etc) likely influenced those results.

Although bony malalignment in general may not be considered a universal finding of PFP,[41] this factor appears to have major relevance, at least in a subgroup of patients with PFP. In approximately 5% (23/522) of our clinical population, severe trochlear dysplasia was deemed the most relevant factor for the etiopathogenesis of chronic PFP and was considered worthy of operative correction. This finding indicates that in most cases, factors other than trochlear dysplasia are more crucial to the problem of PFP. However, the clinical impact of a dysplastic trochlea on

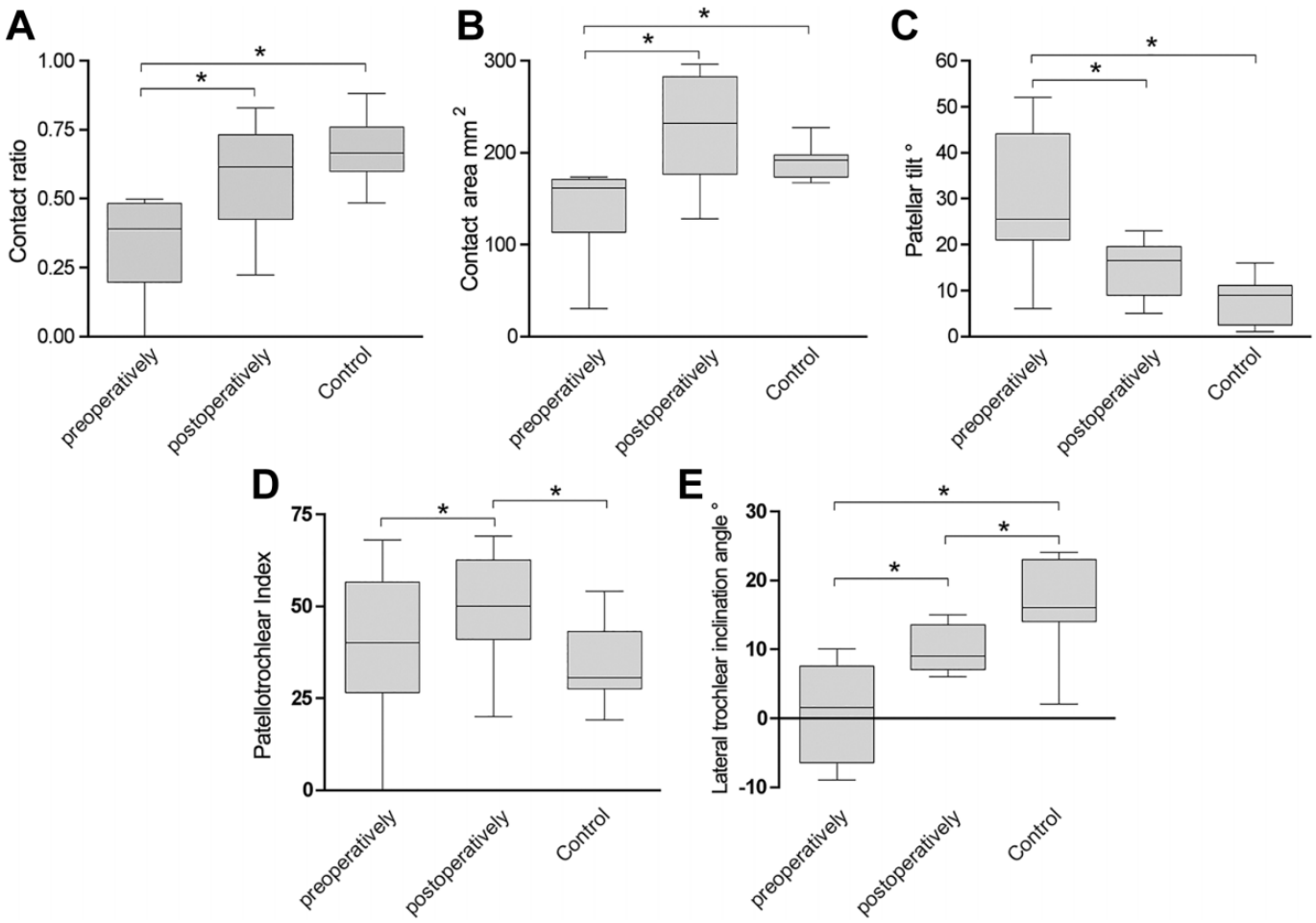

Figure 3. The (A) patellotrochlear contact ratio, (B) patellotrochlear contact area, (C) patellar tilt, (D) patellotrochlear index, and (E) lateral trochlear inclination angle before and after deepening trochleoplasty and compared with those in the control group. *Statistically significant difference ($P < .05$).

patellofemoral biomechanics and PFP has been suggested by previous reports[8,26,32] and is underlined by the encouraging results found in this study. This study also provides some reasonable support to previous investigations that found that PFP is often not a self-limiting disorder, demonstrating a high number of unfavorable outcomes and persistent symptoms.[19] In this regard, we consider PFJ malalignment to be of major relevance when it accompanies PFP. Accordingly, significant improvements in chronic PFP have also been reported after correction of torsional malalignment or patella alta.[1,22]

Whether PFP increases the long-term risk for PFOA is currently debated.[15,23,47] In young patients, PFP is typically not associated with differences in PFJ cartilage composition or structural abnormalities.[49,50] On the other hand, Collins et al[14] found radiographic and MRI-defined PFOA in 20% to 30% of patients aged 26 to 50 years with persistent PFP. Increasing evidence suggests that morphological abnormalities are related to the differences in alignment between patients with PFOA and controls,[30,31,35] particularly when the features of patella alta, lateral patellar displacement, and increased lateral patellar tilt are present.[52] Although PFJ malalignment appears to induce increased contact pressure and cartilage shear stress, the mechanism by which an increased joint load contributes to PFP is not completely understood.[41] In young patients, malalignment with an altered joint load may cause pain and may precede structural abnormalities, which might develop into PFOA in a distinct subgroup of patients later in life.[52] However, PFOA was noted in 30% of patients treated with a trochleoplasty procedure,[33] but the current literature remains inconclusive regarding any link between trochleoplasty and PFOA.[45]

The results of this study must be interpreted under the consideration of several limitations. First, this investigation represents the short-term results of a pilot study with a small sample size, and the findings must be confirmed to remain stable over a medium- to long-term follow-up period. However, the results thus far have encouraged us to continue surgically treating these particular patients. Overall, a total of 23 patients with chronic PFP have been treated with deepening trochleoplasty to date, with 4 more

patients completing the 1-year follow-up. Similarly, the patients reported significant improvements in terms of PFP and had increased Kujala scores within the first year after amendment of patellotrochlear congruence.

Second, we used the Kujala score for clinical evaluations, and whether this score can capture the complex nature of PFP may need to be discussed. However, this score is well-established in the literature and allows comparisons between the pre- and postoperative statuses of the study group in reference to normative values. The newly developed PFP and osteoarthritis subscale of the Knee injury and Osteoarthritis Outcome Score (KOOS-PF) will probably be a useful addition in future research.[17]

Third, improved patellotrochlear congruence after deepening trochleoplasty has been reported previously,[4] and publication of these findings might appear redundant. However, the trochleoplasty procedure is a new approach in the portfolio of PFP treatment, and this study is just about the second investigation that shows this effect. As improvement of patellotrochlear congruence represents a main issue in this investigation, we considered demonstrating changes in patellotrochlear congruence in this particular group of patients to be mandatory.

Fourth, the assessment and classification of a dysplastic trochlea remain major challenges. Tscholl et al[48] showed that trochlear dysplasia measured on lateral radiographs and MRI demonstrated only fair agreement. In addition, quantitative single-measurement parameters of the femoral trochlea seem to be of limited value for the assessment of the complex trochlear anatomy; however, the LTI angle is rated as the most appropriate measure by an expert panel.[38]

Fifth, deepening trochleoplasty was not the only surgical procedure performed. The addition of different procedures causes potential heterogeneity and possible bias in the assessments. The study group was characterized by heterogeneity in terms of combinations of and differences in anatomic pathology. In this regard, PFP due to patellofemoral malalignment exhibits overlapping characteristics with patellar instability, and a tailored treatment approach has been demonstrated to be the key to success in these multifactorial disorders, with trochleoplasty considered the most impactful procedure for the patients in this case series. However, in 6 patients (AMZ, n = 4; distalization, n = 2), concomitant TTO was considered necessary, which also influenced the results. Finally, postoperative MRI investigation was available in only 12 of 15 evaluated patients. It cannot be ruled out that a higher number of postoperative MRI investigations would lead to different results.

CONCLUSION

In a subgroup of patients with chronic PFP due to severe trochlear dysplasia, deepening trochleoplasty and concomitant realignment procedures can significantly reduce pain and improve subjective knee joint function while normalizing patellotrochlear congruence.

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