Osteochondral Fractures in Acute Patellar Dislocations in Adolescents

Midterm Results of Surgical Treatment

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Background: Osteochondral fractures (OCFs) are common injuries during acute patellar dislocation (APD), carrying a high risk of early joint deterioration if left untreated. The recommended approach is reduction and stable fixation; however, data on the results of such treatment are limited.

Purpose: To evaluate midterm results of fixation of APD-related OCFs in adolescents and to identify predictive factors for poor outcomes.

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

Methods: This was a retrospective analysis of adolescent patients who underwent internal fixation of APD-related OCFs between 2004 and 2015 at a single tertiary pediatric trauma center. The primary outcome variables included Knee injury and Osteoarthritis Outcome Score (KOOS), patient satisfaction (0-10 scale), and sports participation compared with preoperative level. Secondary outcome variables included relationship between final results and OCF location (patellofemoral vs tibiofemoral), surgical delay (>6 weeks), and patellar instability after OCF fixation. OCF healing was evaluated using magnetic resonance imaging (MRI).

Results: Included were 40 patients (19 female, 21 male) with 42 OCFs (29 patellar OCFs, 13 lateral femoral condyle OCFs). The median patient age at surgery was 14.5 years (interquartile range [IQR], 13-15.5 years), and median follow-up was 76 months (IQR, 52.5-95 months). Recurrence of patellar instability occurred in 27.5% of patients. Median overall KOOS was 93.8 (IQR, 90.8-97.6); KOOS–Symptoms, 92.9 (IQR, 85.7-96.4); KOOS–Pain, 97.2 (IQR, 91.7-100); KOOS–Activities of Daily Living, 100 (IQR, 97.1-100); KOOS–Sports, 90 (IQR, 80-100); and KOOS–Quality of Life, 78.1 (IQR, 56.2-87.5). Median satisfaction score was 8 (IQR, 8-9), and 16 patients (40%) returned to sports participation at their preinjury level. MRI scans revealed a 100% rate of bone healing. Abnormalities exceeding the fracture area were evident on MRI scans in 86.5% of patients. Recurrence of patellar instability (even after surgical fixation) and unstable patella at final follow-up were independent predictors of worse results after OCF fixation.

Conclusion: In the current study, reduction and internal fixation for APD-related OCF in adolescents yielded favorable midterm outcomes. Recurrence of dislocation and persistent patellar instability jeopardized clinical results.

Keywords: patellar dislocation; osteochondral fracture; healing rate; predictive factors

Osteochondral fractures (OCFs) to the patella and/or lateral femoral condyle (LFC) are among the most common injuries during acute patellar dislocation (APD). Based on arthroscopic findings, Nomura et al[39] reported a 76% incidence of osteochondral defects in a subset of patients with first-time APD. Such defects result in loss of articular congruence that triggers early patellofemoral (PF) osteoarthritis along with postinjury biological cartilage changes, lateral patellar maltracking, and recurrent instability.[1,18,34,44,53]

Reconstruction of PF cartilage constitutes a special challenge, given unique individual anatomic characteristics, thickness of the patellar cartilage, and extreme shearing and compressive forces experienced during flexion activities.[7] Most reported results of PF cartilage reconstruction are inferior compared with those of reconstruction of the tibiofemoral (TF) compartment or indicate unacceptably high rates of reoperation.[10,21,40] An additional issue is the specific nature of APD-related cartilage injury, which frequently involves subchondral bone. This limits cell-based or bone marrow–based therapies,

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requiring technically challenging constructs to restore the bone loss. Osteochondral autograft transfer has been advocated in such cases to replace both cartilage and bone; however, best results are achieved in small lesions (<2 cm^2).[7,21] Osteochondral allograft transplant also has been described for PF defects, with significant clinical improvement in the short term but high failure rates from a longer perspective.[31]

Open reduction and internal fixation has been postulated to be an optimal first treatment option for APD-related OCF.[3,5,7,9,17,27] However, a paucity of long-term, high-volume, and etiologically homogeneous data are available to support such an approach. Most data are from small case series that had short follow-up and/or included both adult and pediatric patients.[28] The quality of the available data makes it difficult to draw unequivocal conclusions.[9,28,54] This is especially true for adolescents, who are at highest risk for APD and OCF.[28,45] However, adolescents are believed to have a high healing capacity that makes it possible to attempt refixation even if delayed or for pure chondral fractures.[5,13,14,22,36,48] Re-creation of a congruent articular surface composed of native hyaline cartilage may be especially beneficial in that group, considering their higher functional requirements and longer life expectancy relative to adults.

The aims of this study were (1) to analyze clinical results of OCF fixation in a large, homogeneous cohort (exclusively pediatric and adolescent patients with first-time patellar dislocation, treated surgically via loose body fixation) with mid-term follow-up; (2) to assess healing status and pathological changes of cartilage via magnetic resonance imaging (MRI) scans; and (3) to define and stratify risk factors for poor outcome.

METHODS

Study Design and Population

After institutional review board approval was obtained, a retrospective chart review was performed to identify all patients treated operatively for APD-related OCF at a tertiary pediatric orthopaedics and trauma department between 2004 and 2015. The inclusion criteria were (A) documented first-time APD with associated OCF warranting refixation; (B) no other concomitant intra-articular lesions (ie, meniscal, ligamentous); (C) any subsequent patellar stabilizing surgery (if performed) done >18 months before final evaluation; (D) minimum 3-year clinical follow-up after index procedure; and (E) complete clinical data.

Criteria for loose body fixation (noncomminuted; the cartilaginous part >1 cm^2; the smallest diameter >8 mm) were

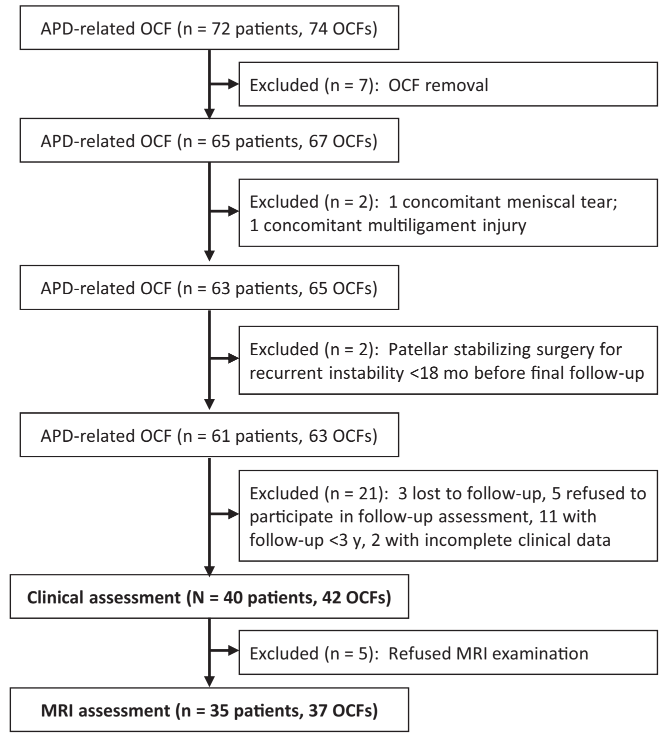

Figure 1. Flowchart of patient enrollment. APD, acute patellar dislocation; OCF, osteochondral fracture. MRI, magnetic resonance imaging.

established based on the results of imaging studies (MRI, ultrasonography).[15] If any doubts existed regarding eligibility of the fragment for fixation, arthroscopic confirmation was performed as a first step of index surgery.

Of 72 possible patients, 65 patients had undergone OCF fixation. Two patients had concomitant injuries addressed at the time of index surgery and were excluded; a further 2 patients had undergone secondary patellar stabilizing surgery (medial PF ligament [MPFL] reconstruction) close to the final assessment, and their recovery was not considered to be completed. In addition, 21 patients were excluded because of logistical reasons: loss to follow-up (n = 3), refusal to participate (n = 5), inadequate follow-up (n = 11), or incomplete clinical data (n = 2). This left 40 patients to be enrolled in the study (Figure 1).

Fixation Technique

All surgeries were performed by 1 of 2 surgeons (J.F. or B.K.). The fragment was reduced and stabilized via an anteromedial arthrotomy approach (Figure 2). Before

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Ethical approval for this study was obtained from the Bioethics Committee at the District Medical Chamber of Krakow (ref No. OIL/KBL/29/2017).

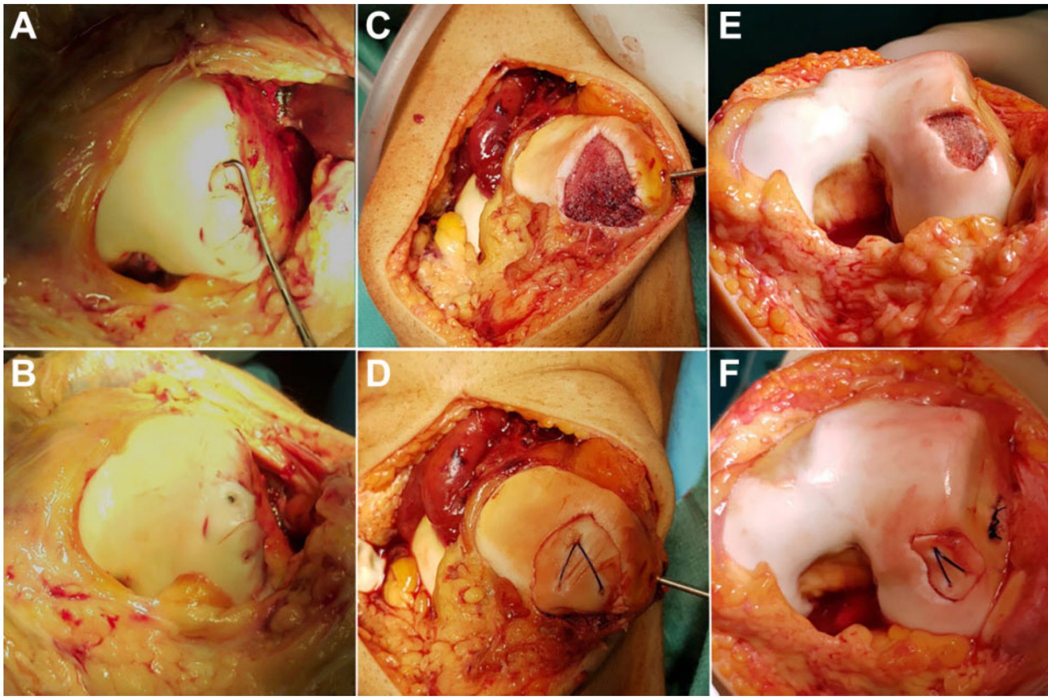

Figure 2. Stabilization of osteochondral fractures: (A and B) lateral trochlea, fixed with smooth, absorbable pins; (C and D) inferomedial patella, fixed with resorbable sutures; and (E and F) weightbearing portion of the lateral femoral condyle, fixed with resorbable sutures.

reduction, the bone bed and loose body were refreshed to enhance healing. Trimming of the fragment and defect edges and curettage of the defect bed were also performed if necessary to precisely level the refixed fragment with surrounding cartilage.

The first 3 consecutive OCFs were stabilized via bioabsorbable devices: multiple smooth pins (OTPS biodegradable pins; Inion Ltd) for 2 cases and headless screws (ReUnite orthopaedic screws; Biomet Orthopedics) for 1 case (Figure 2, A and B). The remaining OCFs were stabilized via transosseous, absorbable monofilament sutures (PDS No. 0; Ethicon) passed through 2 mm–diameter bone tunnels (drilled with smooth K-wire) and tied securely over the ventral surface of the patella (for patellar lesions) or the outer surface of the LFC (Figure 2, C-F).

Concomitant supplemental procedures were performed at the surgeon's discretion and included the following: medial retinacular repair at the patellar attachment in a pants-over-vest fashion (n = 21), MPFL reconstruction (n = 1), Roux-Goldthwait distal realignment (n = 2), and osteochondral autografting of the LFC defect (refixation of a large [>2.5 cm diameter] fragment supplemented by a single 6-mm osteochondral plug from the ipsilateral knee) (n = 1).

Postoperative Protocol

No immobilization was applied after surgery. Physical therapy began as soon as wounds healed and pain and edema were reduced. The rehabilitation protocol for the first 6 weeks included weightbearing as tolerated plus flexion limitation to 70° for patellar lesions or lateral trochlear PF joint (LFC-PFJ) lesions and toe-touch weightbearing plus range of motion progression as tolerated for TF (LFC-TF) lesions. After that period, patients were allowed progressive return to full daily activities. Gradual return to sports (RTS) was allowed from the fourth month after surgery on an individual basis.

Final Assessment

Only patients who agreed to participate in an in-person clinical evaluation were enrolled. Chart review was performed before examination to obtain descriptive data (sex, age at surgery, laterality) and treatment details (OCF location, surgical delay, quality of bony part of the OCF). All participants were examined by an orthopaedic fellow (M.S.) who was not involved in the treatment. The operated knee was examined for range of motion, effusion, and quadriceps atrophy, and patellar stability was assessed via the apprehension test (negative apprehension, +, ++, or +++). Retropatellar crepitations during range of motion and retropatellar pain on compression were noted (Table 1).

All historical information (post–index surgery instability episodes and surgical procedures) was collected from the medical records before final follow-up and/or during subjective patient reporting at the time of final assessment. During the visit, patients were asked about any additional surgeries or emergency department visits outside our institution, and any additional medical records were

TABLE 1
Clinical Examination

Severity of the detected abnormalities	Mild	Moderate	Severe
Flexion deficit (side-to-side difference)	≤10°	≤20°	>20°
Effusion (stroke test): presence of medial parapatellar bulge with lateral suprapatellar downstroke	Medial bulge present with downstroke	Effusion spontaneously returns to medial side after upstroke	Not possible to move the effusion out of the medial aspect of the knee
Quadriceps atrophy: side-to-side difference in thigh circumference 5 cm proximal to the base of the patella	≤1 cm	≤3 cm	>3 cm
Retropatellar crepitations during range of motion (graded by examining physician)	Mild	Moderate	Severe
Pain on Clarke test (graded by patient)	Mild	Moderate	Severe
Apprehension sign in extension	+ (verbal anxiety)	++ (grabbing the knee)	+++ (grabbing the examiner's hand or involuntarily contracting quadriceps)

requested to complete the data. The patients' charts were searched for possible complications, both technique-related complications (eg, need for early reoperation to remove or refix loose body, prolonged effusion) and general surgical complications (surgical-site infection, wound healing problems, stiffness, deep vein thrombosis). Standard knee MRI scans were ordered (1.5-T proton-density, fat-suppressed, turbo spin-echo [TSE]; standard knee coil; 3-mm slice thickness; sagittal, coronal, and transverse sections; T1-TSE sagittal, T2-TSE sagittal and coronal, and T2-weighted gradient-echo sagittal sequences) and were then evaluated by a musculoskeletal radiologist (L.W.).

Outcome Measures

Our primary outcomes of interest were the Knee injury and Osteoarthritis Outcome Score (KOOS); self-reported overall satisfaction with knee function (0-10 scale, with 10 being very satisfied); and RTS level, which we dichotomized (lower vs same/higher level compared with the preinjury level). All scores were stratified according to the following parameters:

1. OCF location: LFC-TF (located on the TF part of the LFC [posterior to the Outerbridge ridge based on operative records and/or posterior to the capsular margin of the anterior horn of the lateral meniscus on sagittal MRI scans]) versus PF fractures, either from the patella or the trochlea (LFC-PFJ) (Figure 2). Knees with coexistent patellar and LFC-TF fractures were excluded from this part of the analysis.
2. Delayed treatment, indicated by surgery >6 weeks after injury.
3. Patellar instability after index surgery, as indicated by the following:

   (a) Recurrent dislocation.
   (b) Patellar instability during last follow-up: an apprehension sign ++ or +++ indicated instability, and an apprehension sign negative or + indicated a stable patella.

Secondary outcomes of interests included following radiological parameters:

1. OCF healing and surrounding cartilage changes as evaluated using the MOCART (magnetic resonance observation of cartilage repair tissue) scoring system (100 points total).[35,52]
2. Occurrence and severity of anatomic patellar instability factors (APIFs): trochlear dysplasia (lateral trochlear inclination <11°),[8,41] patella alta (patellotrochlear index [PTI] <12.5%),[4] and tibial tubercle lateralization (tibial tubercle–trochlear groove [TT-TG] distance >18 mm).[6,47] The incidence and severity these APIFs were compared in patients with versus those without patellar instability.

Statistical Analysis

Statistical analysis was performed using Statistica Version 13.1 (StatSoft Inc). The data normality distribution was assessed using the Shapiro-Wilk test. Nonparametric tests were applied because of rejection of the normality hypothesis for most of the analyzed indices. The skewness values exceeded the absolute value of 2, which indicates a significant deviation of the results from the Gaussian curve. For all statistical tests, the threshold for significance was set at $P \leq .05$.

Differences in the number of patients, categorized by criteria defined in this study, were compared using a contingency table, and the results were assessed based on the chi-square test with Yates correction. Clinical outcomes were dichotomized according to the following predictive factors: OCF location (LFC-TF vs other), delayed surgery (yes vs no), recurrence during follow-up (yes vs no), and patellar instability according to apprehension sign ++ or +++ at last follow-up (yes vs no). The differences between groups were then calculated using the Mann-Whitney U test (for KOOS and patient satisfaction) or chi-square test with Yates correction (for RTS rate). The differences in incidence of APIF and severity on MRI scans between patients with versus those without patellar instability were compared using the chi-square test with Yates correction and the Mann-Whitney *U* test, respectively.

RESULTS

Overall, 40 patients completed final clinical evaluation (21 male, 19 female). A total of 42 fractures (29 patella, 4 LFC-PFJ, 9 LFC-TF) were included. Patellar and LFC-TF fractures coexisted in 2 knees. A total of 3 fragments (1 LFC-TF, 2 patellar) were considered pure chondral (macroscopically and/or radiologically). Fixation was performed at a mean of 7 days (range, 1-93 days) after injury. In 7 cases, surgical delay exceeded 6 weeks. The median age at the time of surgery was 14.5 years (interquartile range [IQR], 13-15.5 years; range, 10-17.5 years), and the median follow-up was 76 months (IQR, 52.5-95 months; range, 42-143 months). At the time of final evaluation, 5 patients were younger than 18 years, and the youngest was 15.5 years.

TABLE 2
Physical Examination Findings[a]

Severity of the detected abnormalities	Mild	Moderate		Severe
	0	+	++	+++
Flexion deficit	39 (97.5)	0 (0)	0 (0)	1 (2.5)
Effusion (stroke test)	40 (100)	0 (0)	0 (0)	0 (0)
Quadriceps atrophy	28 (70)	11 (27.5)	1 (2.5)	0 (0)
Retropatellar crepitations	16 (40)	11 (27.5)	12 (30)	1 (2.5)
Pain on Clarke test	23 (57.5)	8 (20)	9 (22.5)	0 (0)
Apprehension sign in extension	26 (65)	5 (12.5)	7 (17.5)	2 (5)

[a]Data are reported as n (%).

TABLE 3
KOOS Results[a]

	Median	Range	IQR	SD	Skewness
Overall KOOS	93.8	45.8-100	90.8-97.6	9.4	–3.3
KOOS–Symptoms	92.9	53.6-100	85.7-96.4	10.4	–2.1
KOOS–Pain	97.2	44.4-100	91.7-100	9.1	–4.4
KOOS-ADL	100.0	52.9-100	97.1-100	7.8	–4.9
KOOS–Sports	90.0	25.0-100	80.0-100	19.2	–1.9
KOOS-QOL	78.1	18.8-100	56.2-87.5	19.6	–0.8

[a]ADL, Activities of Daily Living; IQR, interquartile range; KOOS, Knee injury and Osteoarthritis Outcome Score; QOL, Quality of Life.

Clinical Results

On physical examination, retropatellar pain was present in 17 patients (42.5%) and/or crepitations in 24 patients (60%). Symptomatic patellar instability (apprehension test ++ or +++) was noted in 9 patients (22.5%) (Table 2). The KOOS results are shown in Table 3. Satisfaction scores ranged from 5 to 10, with a median value of 8 (IQR, 8-9).

Overall, 16 patients (40%) were able to return to their preinjury level of sports, whereas 24 patients (60%) did not. In 10 patients (25%) who did not RTS, this was related to subjective deterioration of knee function and/or pain. The remaining 14 patients who did not RTS reported reasons not directly related to knee functional status (most often the reason was anxiety regarding repetitive trauma).

A persistent flexion deficit of 25° was noted in 1 patient, and no other surgical complications were reported.

Outcome Predictors

Table 4 shows results of the analysis of outcome predictors according to clinical scores. These can be summarized as follows:

1. OCF location: A significantly higher KOOS–Symptoms score was seen for OCFs at the LFC-TF location than at other locations ($P = .02$). No differences were found in remaining KOOS subscale scores or in the satisfaction score.
2. Delayed surgery: No differences (or statistical trend toward significance) were seen in KOOS results or satisfaction score between delayed (>6 weeks) and nondelayed fixation groups.
3. Patellar instability:

TABLE 4
KOOS and Satisfaction Scores for Analysis of Outcome Predictors[a]

	OCF Location			Delayed Surgery			Recurrence			Patellar Instability		
	LFC-TF (n = 7)	Other (n = 31)	*P*	No (n = 7)	Yes (n = 33)	*P*	Yes (n = 11)	No (n = 29)	*P*	Yes (n = 9)	No (n = 31)	*P*
Overall KOOS	96.4	93.2	.41	90.5	94.6	.32	90.5	95.8	**.02**	90.5	95.8	**.006**
KOOS–Symptoms	96.4	92.9	**.02**	85.7	92.9	.23	85.7	92.9	**.01**	89.3	92.9	.12
KOOS–Pain	97.2	94.4	.26	94.4	97.2	.65	94.4	97.2	.08	94.4	97.2	.15
KOOS-ADL	100	100	.22	100	100	.52	100	100	.35	98.5	100	.33
KOOS–Sports	95.0	90.0	.21	80.0	90.0	.17	70.0	95.0	**.03**	90.0	95.0	.43
KOOS-QOL	81.3	75.0	.67	68.7	81.2	.38	62.5	81.3	**.02**	56.3	81.3	**.005**
Patient satisfaction	9.0	8.0	.37	8.0	8.0	.26	8.0	9.0	**.05**	8.0	9.0	**.02**

[a]Boldface *P* values indicate a statistically significant difference between the groups compared ($P \leq .05$). Values reported as median. ADL, Activities of Daily Living; KOOS, Knee injury and Osteoarthritis Outcome Score; LFC-TF, tibio-femoral part of LFC; OCF, osteochondral fracture; QOL, Quality of Life.

TABLE 5
Distribution and Severity of Anatomic Patellar Instability Factors (n = 35 Patients)[a]

	No Patellar Instability (n = 17)	Patellar Instability (n = 18)	*P*
LTI <11°			
Mean (range)	9.1 (2 to 19)	6.1 (–5 to 17)	.874
% pathological (n)	53.0 (9)	66.7 (12)	.629
TT-TG distance >18 mm			
Mean (range)	14.5 (8 to 23)	16.2 (11 to 21)	.551
% pathological (n)	23.6 (4)	44.4 (8)	.344
PTI <12.5%			
Mean (range)	47.9 (18 to 76)	31.1 (2 to 56)	**.012**
% pathological (n)	0 (0)	22.2 (4)	**.039**

[a]Boldface *P* values indicate a statistically significant difference between the groups compared ($P \leq .05$). LTI, lateral trochlear inclination; PTI, patellotrochlear index; TT-TG, tibial tubercle–trochlear groove.

(a) Recurrent dislocation occurred in 11 patients, and in all but 1 patient it led to patellar stabilizing surgery (MPFL reconstruction). Patients with recurrence had significantly worse overall KOOS, KOOS–Symptoms, KOOS–Sports, and KOOS-QOL results compared with patients with no recurrence ($P \leq .03$ for all). Patients with recurrence also had a significantly lower satisfaction score ($P = .05$).

(b) Patients with patellar instability at the final follow-up scored significantly worse on the overall KOOS and KOOS-QOL ($P < .01$). They also had a significantly lower satisfaction rate compared with the rest of the group ($P = .02$).

The RTS rate was not affected by any of the analyzed variables (OCF location, delayed surgery, or patellar instability).

MRI Results

MRI examination was performed in 35 patients (including 2 with concomitant LFC and patellar OCFs). A total of 5 patients declined to undergo MRI; all of them had a stable patella at clinical examination and no recurrences.

Complete healing, defined as an integration of fractured fragment to bone bed, was present in all cases (100% bone healing rate). Patients had a median MOCART score of 85 (IQR, 67.5-95; range, 10-100). In all patients (including those with pure chondral fractures), significant cartilage and/or subchondral bone abnormalities were observed. Of 37 OCFs, 32 fractures (86.5%) were diffuse, extending beyond the fracture zone.

As to APIF distribution, at least 1 risk factor was evident in 34.3% of patients, 2 risk factors (in any configuration) were present in 17.1%, and all 3 risk factors were present in 17.1%. The prevalence and severity of APIFs were higher in the recurrent patellar instability group; however, the values reached statistical significance only for patellar height (Table 5).

DISCUSSION

The most important finding in the present study is that reduction and stable fixation of APD-related OCFs resulted in generally satisfactory midterm clinical outcomes and low complication rates in young active individuals. However, up to 30% of patients reported some concerns with knee function and/or abnormalities during clinical examination at the last follow-up. Moreover, MRI assessment, apart from showing a 100% bone healing rate, revealed cartilage pathology in the majority of patients. Thus, considering the patients' young age (the oldest were in their mid-20s during the last follow-up), potentially high-level athletic expectations in that age group, and the relatively short follow-up period, these results must be interpreted with caution, and some deterioration with time may be expected.

Many technical issues regarding optimal strategy have been discussed in the current literature. Regarding OCF fragment size, strict criteria to indicate fixation remain elusive.[26,27,32,55] In our series, an OCF qualified for refixation if it was noncomminuted, the cartilaginous area was >1 cm^2, and the smallest diameter was >8 mm, regardless of the volume of the subchondral osseous part. Smaller fragments were removed arthroscopically or left in place (if stably entrapped in synovium). Our assumption was that defects <1 cm^2 heal and function well in the long term, specifically in young individuals.[7]

Several fixation techniques have been reported. The goals are to obtain anatomic reduction, provide compression, and ensure rotational stability, thus facilitating healing and allowing early range of motion exercises.[5] Successful OCF fixation has been reported with metal devices (intra-articular screws, headless screws)[23,33] and with a wide variety of bioabsorbable implants: pins (smooth, barbed), screws, anchors, and meniscal arrows.[9,14,30,32,48,54,56] The lack of comparative studies with long-term follow-up precludes recommendation of any one implant over another.[28] Metal screws provide high compression and stability; however, abrasive wear of the corresponding articular surface may occur, as well as breakage of smaller fragments during screw insertion. Metal screws

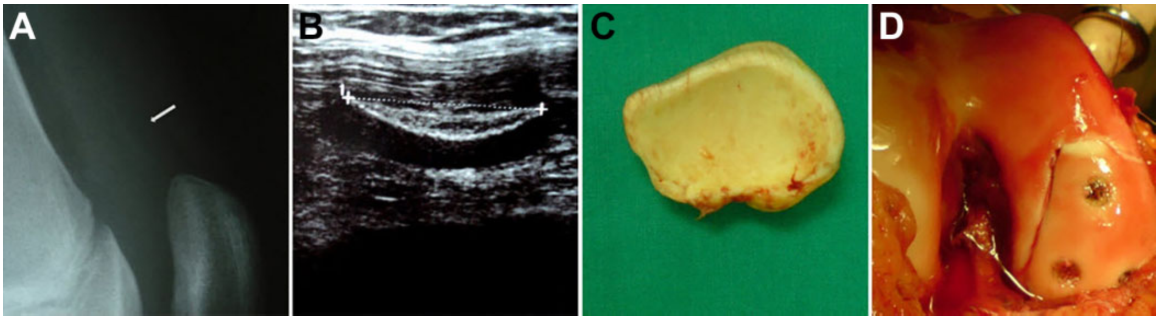

Figure 3. (A) Chondral fracture on radiograph, with contour of the fracture (calcified cartilage layer) barely visible (arrow). (B) On ultrasonography, the same fragment is clearly visible with no acoustic shadow below. (C) Intraoperatively, no osseous tissue was apparent on the bone bed–facing surface. (D) Fracture refixed with 3 bioabsorbable screws.

may necessitate a secondary procedure (for hardware removal) and may hinder MRI interpretation. Bioabsorbable implants are free from those drawbacks but raise concern regarding insufficient compression.[31] In addition, cyst formation has been reported as a result of rapid absorption, and the possibility of allergic reaction must be noted.[31] In the current study, in all but the first 3 cases, we routinely used transosseous absorbable sutures to perform fragment refixation, as previously reported.[5,9,12,37] This technique provides sufficient compression and stability to allow early range of motion exercises; as well, low-profile implants do not damage adjacent articular surfaces or cause MRI interference, and their gradual absorption precludes the need for a second-stage procedure. The cost-effectiveness of this technique is also notable. Our results (100% rate of MRI-confirmed healing) support the use of transosseous absorbable sutures for refixation of APD-related OCFs.

Another discussed issue is the relationship between surgical delay and healing rate. It has been postulated that fixation should be attempted acutely, ensuring conditions conducive to a healing environment, avoiding fibrocartilaginous scar formation inside the defect, and preventing enlargement of the fragment.[9,23,27,48] Concern has been raised as to the long-term viability of the cartilaginous as well as the osseous part of the loose body.[1,25] However, successful healing after delayed OCF fixation has been reported.[5,13,22] In our series, 7 of 42 reported OCFs (17%) underwent refixation >6 weeks after injury, with the longest time lapse >3 months. All of these fractures healed, and the outcome scores in the delayed fixation group did not differ significantly from the rest of the sample (Table 4). Thus, we do not consider surgical delay to be a limiting factor for OCF fixation if other criteria are fulfilled (eg, size, condition of the OCF and bone bed) and specific technical issues are addressed (eg, fragment size readjusted, fracture surfaces refreshed to enhance healing).

Regarding the quality and volume of the osseous part of an OCF, contrary to previous concerns,[5] it has been recently shown that even pure chondral fractures in adolescents heal well.[14,36,48] This is supported by our results—all 3 pure chondral fragments that underwent refixation united uneventfully (Figure 3). Given the small sample size, we did not conduct statistical analysis for this subgroup.

Of the analyzed variables, subsequent patellar instability was the main factor adversely affecting functional results in this study. Lower scores for the overall KOOS, KOOS–Symptoms, KOOS–Sports, KOOS-QOL, and patient satisfaction were noted in patients (n = 11) who had recurrence of patellar instability after index surgery, despite 10 patients having had secondary, patellar stabilizing procedures (MPFL reconstruction) resulting in a stable patella in 9 patients at final follow-up (apprehension sign negative or +). The explanation for low scores in this group may be multifactorial. Cumulative cartilage damage is known to occur with recurrence of patellar instability, and the number of dislocation episodes strongly correlates with the prevalence and severity of osteoarthritis.[1,18,46,53] Additionally, all but 1 patient in this group had undergone additional surgery to stabilize the patella; permanent impairment due to excessive scar formation and/or lack of confidence in knee function due to repeated surgeries may contribute to less satisfactory outcomes. Further, 9 patients who had patellar instability at final follow-up (apprehension sign ++ or +++) also had significantly lower results regarding overall KOOS, KOOS-QOL, and patient satisfaction. This negative effect of persistent patellar instability was evident even when using the KOOS questionnaire, which is not specific to patellar instability disease. However, we chose the KOOS as an outcome measure because the primary aim of the study was to evaluate consequences of knee injury that can result in posttraumatic osteoarthritis. The aforementioned findings are in accordance with data recently presented by Pedowitz et al,[42] who found a high rate (61%) of recurrent patellar instability in 41 patients who had undergone OCF surgery and significantly worse Kujala and Single Assessment Numeric Evaluation scores in those who experienced recurrences.

In the present series, we analyzed the distribution and severity of APIFs and compared subgroups with stable versus unstable patellae. We chose the lateral trochlear inclination angle to measure trochlear dysplasia,[41] TT-TG distance to assess the lateral vector of the extensor apparatus,[47] and PTI to evaluate patellar height.[4] Although all of the APIFs were more common and more pronounced in the unstable patella group, the numbers reached statistical significance only for PTI (Table 5).

In the present series, 60% of patients did not regain their preinjury level of sport activity. In 25%, the most relevant factors for this limitation were chronic pain and/or functional impairment of the injured knee. This finding indicates that APD with accompanying OCF is a potentially serious injury with longstanding consequences despite relatively high functional outcomes. A further 35% of patients reported limited sports participation due to kinesiophobia, which is a phenomenon well known from data on reconstructive knee surgery.[16] This raises the question whether RTS is an accurate tool for assessment of the function of posttraumatic knee.

MRI scans showed healing of the bony part of the OCF in all patients; however, cartilage abnormalities and subchondral bone pathologies were present in all patients. These abnormalities were severe enough to be detectable even on standard 1.5-T MRI knee scans and most often exceeded the area of acute injury. This finding reflects the complex mechanism of cartilage damage in patellar instability. Primary, massive cartilage injury occurs in acute-phase chondral cracks (fissures) in a large area, and surrounding osteochondral defects have been reported in >80% of patients after primary APD.[39] Acute-phase injury continues for the next 48 to 96 hours and involves chondrocyte necrosis, chondroptosis, and extracellular matrix degradation.[11,19,43,51] Posttraumatic MPFL insufficiency results in chronic lateral patellar maltracking (lateral tilt and translation) with significant loading abnormalities and an increase in lateral facet peak contact pressures.[34,49] As well, preexisting APIFs may contribute to progressive cartilage damage and early PF osteoarthritis.[24,38] Gradual cartilage deterioration over time has been reported after only a single episode of lateral patellar dislocation.[44] Iatrogenic cartilage injuries must be considered a result of direct surgical damage or chronic overload from nonanatomic or technically imperfect procedures.[29,50]

Limitations

Several limitations of this study deserve mention. First, the relatively small patient group and short follow-up may cause the results to be underpowered. This is reflected in differences in KOOS values. The KOOS has a minimal clinically important difference of at least 10 points. Thus, a difference of <10 points, even if statistically significant, could have little or no clinical significance. However, the present study represents the largest published series reporting on results (clinical and MRI) of OCF fixation in a homogeneous group (ie, pediatric and adolescent patients with first-time APD). This study presents the results of a single surgical technique (excluding 3 cases refixed with bioabsorbable devices) with proven efficacy that was free from complications. Some predictors for poor outcome were identified, although the small sample size limited the number of analyses that could be attempted with acceptable type 2 error. Thus, given the high incidence of APD and sparse high-volume data on this issue, our results may contribute to the existing knowledge.

Second, the treating surgeon took part in the final assessment. To diminish the possibility of investigator bias, clinical examination was conducted by an orthopaedic fellow who was not involved in the surgery, and patient-reported outcome measures were used (KOOS, patient satisfaction, RTS at preinjury level).

Third, according to current standards, a much larger number of patients would undergo primary patellar stabilizing surgery at the time of OCF fixation, thus preventing the high prevalence of recurrent patellar instability. The reason for this undertreatment in the present series is that at the time of patient recruitment, contemporary algorithms for care of primary APD (eg, Patellar Instability Severity Score, Recurrent Instability of the Patella score) did not exist.[2,20] Moreover, it was postulated that surgical treatment in those cases carries no benefits over a nonoperative approach (except for OCF refixation).

CONCLUSION

In the current study, a 100% healing rate and satisfactory midterm clinical results were obtained via suture fixation of APD-related OCF in adolescents. However, considering the young age of the study patients, their life expectancy, their long-term requirements for knee function, and the high prevalence of pathological findings on imaging studies (MRI), caution in forming far-reaching conclusions is warranted. Recurrent patellar instability was the main predictor of poor outcome. This supports the theory that apart from OCF fixation, patellar stabilizing surgery should be considered at the time of APD, based on current treatment algorithms.

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