Changes in Patellar Morphology Following Surgical Correction of Recurrent Patellar Dislocation in Children

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Research Article

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Abstract

Background: The aim of this study was to evaluate the morphological changes of patella following surgical correction of recurrent patellar dislocation in children.

Methods: 35 immature children aged 5 to 10 years who suffered from bilateral recurrent patellar dislocation associated with abnormal patella morphology. The knee had most frequently patellar dislocation, which was underwent medial patellar retinacular plasty, and defined as in the study group (SG). The contralateral knee was treated conservatively and defined as in the control group (CG). Computed tomography (CT) scans were performed on all children preoperatively and at the last follow-up to evaluate the patellar morphological characteristics.

Results: All the radiological parameters of the patella, showed no significant difference between the two groups, Preoperatively. At the last follow-up for CT scans, no significant differences were evaluable for the relative patellar width (SG, 54.61%; CG, 52.87%; $p=0.086$) and the relative patellar thickness (SG, 26.07% ; CG, 25.02%; $p = 0.243$). The radiological parameters including Wiberg-angle (SG, 136.25°; CG, 122.65°; $p < 0.001$), modified Wiberg-index (SG, 1.23; CG, 2.65 ; $p < 0.001$), and lateral patellar facet angle (SG, 23.35° ; CG, 15.26°; $p < 0.001$) showed statistical differences between the two groups.

Conclusions: The morphology of the patella can be improved by early surgical correction in children with recurrent patellar dislocation. Early intervention for children with recurrent patellar dislocation is important.

Introduction

The patella plays an important role in human activities. Patellar dislocation is a common medical problem in clinical practice. The incidence of patellar dislocation is highest among children and adolescents, in whom the incidence is 147.7 per 100.000 person-years [1]. Lewallen et al. reported that the redislocation rates among immature patients up to 71% [2, 3]. Jaquith and Parikh found that adolescents with open physis had more than twice the risk of recurrent patellar dislocation compared to patients with closed physis [4, 5]. Dejour et al. showed that 96% of patients with patellar dislocation had trochlear dysplasia [6]. Servien and Li showed that patients with trochlear dysplasia had a patella of smaller width, thinner thickness, more flattened articular facet and increased Wiberg-index [7, 8]. Jaquith and Parikh reported a particularly evident by the fact that the simultaneous presence of a patellar and trochlear dysplasia increases the risk of redislocation to more than 70% [4, 5]. Fu et al. recently showed that early relocation of the patella can prevent the development of trochlear dysplasia in children [9]. However, no authors have described the potential influence of patellar correction on the development of the patella in children. The aim of the present study was to compare the changes in patellar morphology following surgical correction for recurrent patellar dislocation in children.

Material And Methods

The study has been approved by the Ethics Committee and all patients provided informed consent.

All of the children had a history of bilateral recurrent and were diagnosed as involving disruption of the normal position of patella within the trochlea groove because of multiple traumatic episode [10]. These two independent senior orthopedic observer defined the bilateral recurrent patella dislocation on knees. The exclusion criterion was a history of prior surgery or ligament injury or cartilage damage of greater than grade II [11].

35 patients (23 females and 12 males, mean age 7.8 years [range, 5–10]) who had bilateral recurrent patellar dislocation associated with abnormal patella morphology that was diagnosed according to Askenberger M were enrolled [12]. The knee in the study group (SG) was treated with medial patellar retinacular plasty. The contralateral knee was treated conservatively and defined as in the control group. From February 2008 to December 2014, mean follow-up of 78.6 months (62 to 106). The 35 immature patients (mean age 7.8 years [range, 5–10]) with recurrent patellar dislocation underwent surgically or conservatively in the study. CT scans were performed in 35 patients preoperatively and the last follow-up. According to CT images of the knee joint, the morphology of patella were analyzed on particular axial views. All controls consulted the orthopedic surgeon for a complaint, such as soft cartilage injury.

Surgical procedures.

In children, surgical technique have to consider the risk of growth plate injury and open physis [13–15]. Therefore, numerous bony procedures are contraindicated, and soft-tissue procedures are designed to respect the anatomy. The surgical technique employed has been previously described in the study [9]. All surgeries were performed by two senior surgeons. All patients were administered general anaesthesia and arthroscopic assessment by standard procedures to deal with intra-articular lesions before medial patellar retinacular plasty treatment. A medial shift force of the patella of less than one quarter the width of the patella indicates the overtension of lateral retinaculum, the lateral retinacular release needed to undertake in these cases [16]. In SG, eight patients were performed arthroscopic lateral retinacular release. After the diagnostic arthroscopy, the subsequent procedure of medial patellar retinaculum (MPR) plastysurgical is enumerated. First, a 3-cm incision was created on the medial margin of the patella. The vastus medialis oblique (VMO) and the medial patellar retinaculum (MPR) were exposed and dissected. Next, the position and tension of two structures were divided and adjusted appropriately. The patellar trajectory was dynamically observed under arthroscopy. Then, the MPR was sutured on the medial margin of the patella; the VMO was sutured on the edge of the MPR with PDS-II whipstitch. Also, the overlapped tissues were sutured together using PDS-II whipstitch. Finally, the incision were irrigated and sutured in layers.

Rehabilitation.

The rehabilitation process after surgery includes the knee immobilizer for 2 weeks [17–19]. For the first few days, to minimize the risk of arthrofibrosis, continuous passive or active motion should be applied postoperation. Full weight bearing and athletic exercises should be possible 4–10 weeks post operation [20].

Conservative management.

Conservative treatment in CG began meanwhile as the surgery on the contralateral knee. This immobilization in a brace and physiotherapy should be included [21–23]. First, isometric strengthening in closed-chain exercises should be exercised in each conservative patient, which helps to control lateral instability in the tight lateral retinaculum [21–26]. Bitar AC et al. stated that physiotherapy is a key factor that can improve quadriceps strength [24]. McConnell showed good results in conservative patients using physiotherapy and the brace taping technique to modify patellar tracking for 12 months [23]. Therefore, the study involved treatment with physiotherapy and the brace taping technique for more than 12 months were undertaken in these patients everyday.

CT assessments.

CT views assessment of morphological characteristics of patella were performed in the supine position, at preoperatively and and the last follow-up after surgery. CT scans were performed using a Sante DICOM Viewer Free (64-bit) version (Santesoft, Inc. Athens, Greece) to 0.01°for angles and 0.01 mm for distance, and all parameters were assessed utilizing the axial views using 1 mm slices. The relative patellar width, the relative patellar thickness, the wiberg-angle, the modified wiberg-index and lateral patellar facet angle were measured on the particular axial CT scan [8, 27]. The methods applied to the assessment of patellar morphology are summarized in Table 1 and Fig. 1–4. In order to minimize error, all measurements were conducted by two blinded authors (experienced orthopedic surgeons) using the RadiAnt-DICOM software (Medixant Ltd, Poznan, Poland).

Table 1

Description of measurements

patella morphological characteristics	
Medial-lateral width (MLW)	It is defined as the length between the medial (a) and lateral edge (b) of of epicondyle (Fig. 1).
Patellar width (PW)	It is defined as the length between the medial (A) and lateral edge (B) of the patella in the slide with the widest patellar diameter (Fig. 2).
Patellar thickness (PT)	It is defined as the length between the patellar front polar (C) and back polar (D) (Fig. 2).
Modified Wiberg-index (AE/BE)	It is measured as the ratio of the transverse length of the lateral patellar facet (AE) to the medial patellar facet(BE) (Fig. 2).
Wiberg-angle	The angle between the slopes of the medial and lateral patella (Fig. 3).
Relative patellar width (PW/MLW)	The ratio of length of Patellar width to medial-lateral epicondyle width.
Relative patellar thickness (PT/MLW)	The ratio of length of Patellar thickness to medial-lateral epicondyle width.
Lateral patellar facet angle	The angle between the patellar transverse axis (AB) and the lateral patellar facet tangent (Fig. 4).

Statistical analysis

Analysis were performed using SPSS software (version 22.0; SPSS, IL, USA). Descriptive statistics were used to evaluate the distribution of continuous data. The normality of numerical data was assessed by the Kolmogorov–Smirnov test, and the homogeneity of the data was assessed by Levene’s test. After establishing data normality, student's paired t-test were used to evaluate the differences between the two groups. $P < 0.05$ were defined as the threshold for statistical significance.

Results

The inter-and intraobserver correlation coefficients was high between measurements (Table 2).

Table 2

Intra-observer and inter-observer agreement of geometric measurements with 95% confidence intervals

Measurement	Intraobserver		Interobserver	
	ICC	95% CI	ICC	95% CI
pre-SG RPW	0.786	0.673 to 0.935	0.724	0.563 to 0.869
pre-SG RPT	0.806	0.720 to 0.932	0.752	0.595 to 0.912
pre-SG WA	0.843	0.636 to 0.928	0.786	0.527 to 0.904
pre-SG MWI	0.882	0.757 to 0.916	0.757	0.478 to 0.907
pre-SG LPFA	0.973	0.943 to 0.987	0.962	0.921 to 0.987
post-SG RPW	0.795	0.802 to 0.924	0.738	0.773 to 0.906
post-SG RPT	0.762	0.773 to 0.905	0.746	0.736 to 0.918
post-SG WA	0.883	0.753 to 0.960	0.858	0.825 to 0.916
post-SG MWI	0.933	0.913 to 0.965	0.879	0.840 to 0.954
post-SG LPFA	0.976	0.958 to 0.985	0.916	0.827 to 0.969
pre-CG RPW	0.773	0.696 to 0.935	0.735	0.640 to 0.846
pre-CG RPT	0.812	0.784 to 0.942	0.750	0.582 to 0.900
pre-CG WA	0.823	0.753 to 0.931	0.789	0.623 to 0.881
pre-CG MWI	0.830	0.693 to 0.906	0.738	0.527 to 0.864
pre-CG LPFA	0.964	0.953 to 0.974	0.957	0.920 to 0.976
post-CG RPW	0.830	0.759 to 0.965	0.820	0.779 to 0.926
post-CG RPT	0.848	0.738 to 0.942	0.819	0.758 to 0.940
post-CG WA	0.820	0.691 to 0.834	0.784	0.624 to 0.890
post-CG MWI	0.916	0.857 to 0.954	0.903	0.816 to 0.942
post-CG LPFA	0.958	0.926 to 0.985	0.957	0.918 to 0.973

ICC, intra-class correlation coefficient; SG, study group; RPW, relative patellar width; RPT, relative patellar width; WA, Wiberg-angle; MWI, modified Wiberg-index; LPFA, Lateral patellar facet angle; CG, control group

Evaluation indexes of patellar morphology. Preoperatively, the data regarding of patella morphological characteristics were not significantly different for the two Groups (relative patellar width, $p = 0.184$; relative patellar thickness, $p = 0.738$; Wiberg-angle, $p = 0.874$; modified Wiberg-index, $p = 0.076$; lateral patellar facet angle, $p = 0.385$) (Table 3). At the last follow-up, the relative patellar width showed no significant difference (SG, 54.61%; CG, 52.87%; $p = 0.086$) between both groups. The relative thickness was no significant different between the groups, 26.07% in the SG and 25.02% in the CG ($P = 0.243$). In contrast, the mean Wiberg-angle showed highly significant differences between the groups (SG, 136.25°; CG, 122.65°; $P < 0.001$). Significant differences were seen in well-known measurements such as modified

Wiberg-index (SG, 1.23; CG, 2.65; $p < 0.001$). The mean lateral patellar facet angle showed the greater difference: 23.35° in the SG versus 15.26° in the CG ($p < 0.001$) (Table 4).

Table 3

Preoperative evaluation of patella morphological characteristics

Indexes	SG	CG	p-value*
Mean RPW, (SD)	46.67 (7.64)	44.85 (6.85)	0.184
Mean RPT, (SD)	17.75 (4.30)	17.24 (4.78)	0.738
Mean WA, (SD)	165.35 (8.71)	164.65 (8.35)	0.874
Mean MWI, (SD)	1.56 (0.73)	1.32 (0.76)	0.076
Mean LPFA, (SD)	21.65 (2.31)	22.85 (2.15)	0.385

*Student's t-test.

SG, study group; CG, control group; RPW, relative patellar width; RPT, relative patellar width; WA, Wiberg-angle; MWI, modified Wiberg-index; LPFA, Lateral patellar facet angle

Table 4

Follow-up results of patella morphological characteristics

Indexes	SG	CG	p-value*
Mean RPW, (SD)	54.16 (2.76)	52.87 (3.31)	0.086
Mean RPT, (SD)	26.07 (2.05)	25.02 (3.28)	0.243
Mean WA, (SD)	136.25 (7.76)	122.65 (7.31)	<0.001
Mean MWI, (SD)	1.23 (0.18)	2.65 (0.45)	<0.001
Mean LPFA, (SD)	23.35 (3.41)	15.26 (3.66)	<0.001

*Student's t-test.

SG, study group; CG, control group; RPW, relative patellar width; RPT, relative patellar width; WA, Wiberg-angle; MWI, modified Wiberg-index; LPFA, Lateral patellar facet angle

Discussion

The key finding of the current study was that the morphology of patella can be improved by early surgical correction in children with the setting of recurrent patellar dislocation compared with conservative

management. The findings of this study have important clinical reference value for the surgical treatment of recurrent patellar dislocation. As the improvement of patella and femoral trochlear in patients of patellar dislocation may allow for the avoidance of an additional surgical procedure. In children, soft-tissue surgery seems to be the only treatment option, as the tibial and femoral physes may be injured by bony procedures, possibly leading to premature closure [28–31]. In previous studies [28, 32], with the stimulation of bone stress, the patella may match the shape of femoral trochlear and gradually shape after the medial patellar retinacular plasty. With regard to trochlear dysplasia, the result of femoral trochlear morphology can be improved by early surgical correction in children has been well studied [9], but the patella has not been well measured. Fucentese et al. indicated patients with trochlear dysplasia, the patellar had a smaller medial facet, and compared with the control group patella type II and type III had a higher prevalence [33]. Panni et al. found an association between patellar morphology type and femoral trochlear dysplasia grade III and a correlation between patella tilt and patella shape [34]. Li et al. reported that patients with trochlear dysplasia had a patella of smaller width, thinner thickness, more flattened articular facet [8]. Niu et al. studied 40 knees from 20 rabbits that were divided into an experimental group (underwent a medial soft tissue restraint release) and control group (no surgical interventions) [35]. The study demonstrated that the shape and articular surface of the patella became more flattened after patella dislocation in experimental group. However, no authors have observed the potential influence of the femoral trochlea on the development of the patella in children. The capacity for articular remodelling is well known in children as exemplified in the dysplastic knee [29]. So we believe that it is significative to propose that by restoration of more normal biomechanics at the patellofemoral joint the development of the patella can be influenced. As with the hip, our study suggest that remodelling can occur at the patella and this potential is most apparent in children [36].

Patellar morphology were the focus in the study and yielded Meaningful results. The present study showed that the mean Wiberg-angle and the mean lateral patellar facet angle were bigger in the knees after the medial patellar retinacular plasty, while the modified Wiberg-index was smaller in the knees with medial patellar retinacular plasty compared with those with conservative treatments. In the study, the relative patellar width and the relative thickness showed no signifcant diference between both groups, which is consistent with the results of Otto A [27]. In contrast, the mean Wiberg-angle was 136.25° bigger in the SG compared with those conservative treatments (the CG), 122.65°, $p < 0.001$), the modified Wiberg-index was 1.23 smaller in the SG compared with in the CG, 2.65, $p < 0.001$), and the mean lateral patellar facet angle reflected a significant difference between the groups ($p < 0.001$). An significative conclusion can be inferred from these results, that patellar morphology can be remodeled following early surgical correction of patellar dislocation in children. But how to explain this phenomenon and what exactly is the transformation of the patellar morphology?

We know the unique matching relation of the patella and femoral trochlea, patellar mechanical stress is the basis of its biomechanical function [37]. Stress stimulation plays an important role in bone development [38]. In the patellofemoral joint, stress is transmitted from the articular cartilage to the bone, because of stimulus transmission, the remodelling has been documented at the femoral trochlear [9]. Furthermore, Fucentese SF et al. reported that a decreased pulling effect of medial patellofemoral

ligament result in a theoretical shortened medial patellar facet in children [32]. So the patella may be remodeled, when the medial patellofemoral ligament tension returns to normal and the patella rematch the corresponding surface of femoral trochlear. In SG, the patellar morphology was remodeled Similar normalization at the final follow-up, which was not seen in CG (Fig. 5). The reason is that the patella was located in the trochlear groove postoperatively.

There were several limitations to the study. First, CT can be used to describe the osseous structure which cannot be showed the corresponding cartilage surface [39]. Second, the sample size of the study was small, thus the result may be different with a larger study. Third, the single transverse sections were used, which might not effectively describe all the morphological changes of the patella. Consequently, the sagittal sections should also be considered in order of precise evaluation [40].

In conclusion, the present study is the first one comparing patellar morphology in conservative management and surgery in children. The important finding was that compared with conservative management, the patellar morphology can be significantly remodeled to accommodate the patellofemoral joint movement according to early surgical treatment in children with recurrent patellar dislocation.

Abbreviations

SG: study group; CG: control group; CT: Computed tomography; MPR: medial patellar retinaculum; MPR: medial patellar retinaculum; PDS-II: (polydioxanone) synthetic absorbable suture; SPSS: Statistical Package for the Social Sciences; MLW: Medial-lateral width; PW: Patellar width; PT: Patellar thickness; ICC: intra-class correlation coefficient; RPW: relative patellar width; RPT: relative patellar width; WA: Wiberg-angle; MWI: modified Wiberg-index; LPFA: Lateral patellar facet angle; Pre: preoperatively; Post: postoperatively

Declarations

Ethics approval and consent to participate

This study was approved by 1st Central Hospital of Baoding Research Ethics Committee ([2019]-N21) and all patients provided informed consent.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Role of the funding source

The funding sources were not involved in the design, collection, analysis, and interpretation of the data, or in the writing of the manuscript.

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Authors' contributions

WL, QW, HL, and SW were all involved in the conception and design of the study, the acquisition of data, the analysis and interpretation of data, and drafting the article and revising it. All authors read and approved the final manuscript.

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Figures

Figure 1

The medial-lateral width (MLW) is the length between the medial (a) and lateral edge (b) of of epicondyle.

Figure 2

The patellar width (PW) is the length between the medial (A) and lateral edge (B) of the patella. The patellar thickness (PT) is the length between the patellar front polar (C) and back polar (D). The modified Wiberg-index is defined as the ratio of the transverse length of the lateral patellar facet (AE) to the medial patellar facet (BE).

Figure 3

The Wiberg-angle is the angle formed by the medial and the lateral patellar facet tangent.

Figure 4

The lateral patellar facet angle is the angle formed by the patellar transverse axis and the lateral patellar facet tangent.

Figure 5

CT scans of surgically treated in the study group and conservatively treated in the control group. The scans show remodeling of the patella at the last follow-up in SG patients, which was not see in CG. CG, control group; SG, study group; Pre, preoperatively; Post, postoperatively.