Ultrasonographic measurement of the dimensions of proximal and distal patellar fragments after Niebauer-King Procedure for the management of congenital dislocation of the knee

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Abstract

Objective: The aim of this study was to ultrasonographically measure the dimensions of the proximal and distal patellar fragments to determine whether postoperative growth differences exist between the fragments in children with congenital dislocation of the knee treated by Niebauer-King quadricepsplasty.

Methods: This retrospective study included six congenital dislocated knees of four children with arthrogryposis multiplex congenita (AMC) (3 girls; mean age = 40 months; age range = 9–44 months), presented with severe hyperextension knee contractures, which were treated by Niebauer-King’s quadricepsplasty. The transverse, craniocaudal, and anteroposterior dimensions of the patellae were measured ultrasonographically 20 (range = 6–42) months postoperatively by a single radiologist.

Results: The mean transverse, craniocaudal, and anteroposterior dimensions of proximal and distal halves of the patellae were: 11.46 (7.0–16.9)–10.5 (8.0–14.4); 17.4 (14.0–21.0)–16.6 (14.5–19.3); 6.76 (5.6–7.9)–7.76 (7.0–9.4) mm respectively. There was no significant difference in craniocaudal and transverse dimensions, but the anteroposterior dimension (thickness) of the distal patellae articulating the knee joint had a greater thickness (P = 0.01).

Conclusion: Evidence from this study has shown that a better growth can be expected in the distal fragment of the patella compared with the proximal fragment following treatment with Niebauer-King’s quadricepsplasty in children with congenital dislocation of the knee.

Level of Evidence: Level IV, Therapeutic Study

Introduction

Arthrogryposis Multiplex Congenita (AMC) is defined as multiple joint contractures of two or more different parts of body, which are seen in one in five to ten thousand live births.1,2 This syndrome may present itself as internal rotation of the shoulders, elbow extension, wrist and hand flexion, equinovarus feet and knee and hip contractures.3 If not treated, these contractures may lead to severe disability, as the child grows up. So, the main aim in treatment is to resolve the contractures to an acceptable level.1 Treatment requires multidisciplinary approach and should be initiated as soon as possible. Some contractures could be treated with non-operative methods such as serial casting and splinting. However, recalcitrant deformities necessitate surgical intervention.3

Knee involvement is seen in 70% of these patients and knee is the second joint which is mostly affected.4 Flexion contracture is encountered mostly; however, recurvatum deformity with dislocation may also be seen. Patellofemoral joint is also affected. The patellae are displaced laterally and proximally leaving the patellar groove underdeveloped and the patellar ossification retarded.7 Aforementioned deformities restrict the self-ambulation of the patient and should be corrected. Knee extension contractures require quadricepsplasty and release of the anterior capsule if necessary, with the risk of extensive scarring of the extensor mechanism. Severe or neglected deformities may require distal femoral osteotomy.8,9

Quadricepsplasty is performed by an incision extending from the great trochanter to the anterior tibia splitting the fascia lata along its whole length, without using a tourniquet. The quadriceps muscle is mobilized distally as far as the femoral nerve tension allows. It is also advised to secure the rectus if needed.10,11 Niebauer–King’s quadricepsplasty, however, allows tourniquet use, provides an excellent view of the knee joint and the abnormal fibrous tissue under the quadriceps tendon, which is Z-lengthening of the quadriceps and patellar tendons severing the patella, leaving distal medial and proximal lateral halves, but with the potential risk of damage on the patella.12–14 This made us ask if the distal articulating patella grew better than the proximal non-articulating half.
Development of patella after its division into two equal parts was not investigated before. Since patella appears between 3rd and 4th years of age, roentgenography has a limited role in long term evaluation of patellar development. But, ultrasonography has been successfully used in developmental dysplasia of the hip for the determination of the relationship between femoral head and acetabulum, and there are reports about ultrasonography use in evaluation of non-ossified patellae in arthrogryposis and hyperextension deformity of the knee. This paper is a retrospective study on ultrasonographic evaluation of patellae after Niebauer–King’s quadricepsplasty for congenital dislocation of the knees with extension contractures.

Our hypothesis was that the distal half of the patellae grows better than its proximal peer after Niebauer–King’s quadricepsplasty.

Materials and Methods

The informed consents and the institutional review board approval were obtained (Meeting No: 38, Decision No: 13, 2015). There were seven AMC patients with knee hyperextension contractures who were admitted to our institute. All patients were consulted to the pediatric neurology department for any concomitant neurological disorder. After the consultations were concluded, treatment plan was made according to the number of joints affected, severity of the deformities and age when they are referred to the hospital. Serial casting was applied to all patients as the first step of treatment. Two patients were treated successfully with serial casting under general anesthesia. Five patients’ contractures were rigid and did not improve. Besides, they had concomitant rigid DDH or feet deformities which could not be corrected with cast alone. So, surgical correction was decided. The two patients who improved by serial casting and one with hyperextension deformity who was treated by modified Curtis Fisher quadricepsplasty were excluded from the study. Six knees of four AMC patients with amyoplasia, and congenital dislocated knees with severe hyperextension contractures, who were treated by Niebauer–King’s quadricepsplasty were included.

Surgical technique and postoperative rehabilitation

Midline and vertical incision was made from the distal 1/3 of the thigh to tuberositas tibia. After quadriceps and patellar tendons were encountered, longitudinal tenotomy which was begun from the midline of quadriceps tendon and extended through patella and patellar tendon till the tuberositas tibia was made, releasing the tight structures including the anterior capsule (Figure 1). The lateral stump of the patellar tendon was sutured end-to-end to the quadriceps tendon left on the medial quadriceps tendon whose distal patellar tendon insertion was preserved on the tibial tuberosity. The knee was fixed with a 2.5 mm Kirschner wire over 45°flexion. The patellar component of the patellofemoral joint was of the medial half of the patella (Figure 2). Skin was closed by subcuticular absorbable sutures, and a long leg cast was applied for 3 weeks postoperatively, then physiotherapy was begun after Kirschner wire removal. Patients’ patellae were examined by ultrasonography 20 (6-42) months postoperatively. Proximal lateral and distal medial semilunar parts’ transverse, craniocaudal, and anteroposterior dimensions were measured by ultrasonography.

Statistical analysis

Statistical analysis was performed using the statistical package SPSS software (Version 15.0, SPSS, Inc., Chicago, IL, USA). Paired samples t-test was used to compare the data. Values of $P < 0.05$ were considered statistically significant.

Results

The mean age of the patients was 40 (17-59) months. The early postoperative Total Arc of Motion (TAM) was 0-90° in all of the knees, but there was a 20° to 40° decline in the TAM (0-70°) at the latest follow up. Cases 1 and 2 could walk with minimal support. Postoperative functional views can be seen in Figure 3. Developmental Hip Dysplasia (DDH), Vertical Talus and Clubfeet were the accompanying pathologies in the cases. The demographic data, time of surgery, ultrasonography and associated anomalies are given in Table 1.

The transverse, craniocaudal and anteroposterior dimensions of the patellae were measured with ultrasonography, by the same radiologist. Dimensions were determined as 8.0-12.6, 14.5-19.3 and 7.0-9.4 mm, respectively. There was no significant difference in craniocaudal and transverse dimensions, but the anteroposterior dimension (thickness) of the distal patellae articulating the knee joint had a greater thickness ($P = 0.01$). The measurements of the patellae, including the unaffected...
knees of unilateral cases are given in Table 2. The descriptive statistics are given in Table 3. Proximal and distal patellae are seen in the postoperative roentgenogram in Figure 4. Ultrasound images showing anteroposterior dimensions of both inferior medial half and proximal lateral half of the patella are given as in Figures 5 and 6, respectively.

Discussion

AMC is a rare pathology which causes multiple joint contractures. Congenital knee dislocation with extension contracture is seen in 6% of the cases.\(^{1,4}\) The extensor mechanism, which is the quadriceps, joint capsule and the iliotibial band is tight and fibrotic. External rotation and valgus deformity displaces the patella laterally and proximally, and in long standing contractures which may cause epiphyseal and articular deformity, causing early arthritis.\(^{15–17}\)

Quadricepsplasty includes gradual release of the tight tissues. Some authors defend minimal invasive surgeries due to the hypertrophic scar tissue followed by more extensile surgeries which can interfere with the mobilization of the joint.\(^{18,19}\) However neglected deformities lead to necessity of open and aggressive release. Multiple techniques of quadricepsplasty (Z-plasty or inverted V-Y plasty) were described and proved to provide an effective correction. The rigid nature and accompanying pathologies may cause loss in gains in AMC. Providing a community walking patient is the main goal of the treatment.\(^{5,6,20–22}\)

Niebauer–King’s quadricepsplasty was first defined in 1960. They shared the results of 12 patients who were treated because of the congenital knee dislocations. Six knees of four patients were treated with lengthening of quadriceps, patella and patellar tendons. They did not specify the results of the patients but emphasized that the less invasive the treatment the more success was gained.\(^{13}\) We did not apply traction like them but tried to release the contractures with less invasive methods such as casting, however severe contractures remained unresponsive.
Niebauer–King's quadricepsplasty was effective by simultaneous relief of the insufficient and tight knee joint capsule together with the other components of the contracture. Main advantages of Niebauer–King's Quadricepsplasty over modified Curtis Fisher quadricepsplasty was its permitting tourniquet use and providing a direct effective approach to the knee to correct the pathology with a shorter surgery time. Lengthening the whole extensor mechanism including patella helped us gain 90 degrees of flexion immediately after surgery in our series. But there was 20 to 40 degrees decrease in TAM at the last follow-up suitable for a community walker.5 This could be attributed to the slower growth of fibrotic quadriceps tendon and scar tissue than bone, which may limit the range of motion gradually, and should be anticipated in cases with multiple joint involvement with AMC, with the major gain to be the reduction of the knee joint before the maturation is complete.

Patella is a sesamoid bone with an important role in knee extension. It starts ossifying at the ages between 3rd and 4th years of age. Concerns about the divided patella were worthy to investigate if there was a difference between the proximal and distal parts in terms of development. Fortunately, Borowski et al. used ultrasonography to assess patellar position and patellar groove in hyperextension contracture of AMC patients’ knees.7 He reported that the 16 patellae of 16 knees were successfully seen on ultrasonography and none of the patients under 5 years of age had a visualized patella on radiography. He also managed to visualize the relationship between the patella and trochlear groove. Similarly, none of our patients was older than 5 years. So, we also evaluated the development of both the proximal and distal halves of the patella with ultrasonography.

Opposing joint cartilages of bones determine joint growth and maturation. This relationship has already been defined in developmental dysplasia of the hip.15,17 Incongruence of femoral head and acetabulum leads underdeveloped femoral head and shallower acetabulum which ends up with early degeneration. We thought that there was a similar relationship between patella and trochlear groove. In congenital patella dislocation, neglected deformity has already been shown to lead the hypoplastic patella and shallower groove.18–22 Hence, in our patients, distal half of the patella remained in the groove was expected to develop better than its proximal pair. The measurement of the patellae in the unilateral cases showed that the anteroposterior diameter of the distal articulating half was closer to the anteroposterior diameter of the normal side’s patella, than its proximal peer, although statistically insignificant. Patellofemoral joint congruency may have contributed to healthy growth and maturation of patella. Superoinferior and transverse dimensions did not differ between the halves. However, anteroposterior dimension was significantly greater in the inferior articulating half than the superior non-articulating half ($P = 0.01$).

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**Table 1. Demographic Data, Side, Time of Surgery, Ultrasonography, and Associated Anomalies**

| Case | Side | Gender | Age at surgery (months) | Ultrasonography performed post-operatively at (months) | Associated anomaly | Associated surgery |
|------|------|--------|------------------------|--------------------------------------------------------|--------------------|--------------------|
| 1    | R    | F      | 17                     | 42                                                     | Bilateral DDH, Clubfoot, Constrictive Band Syndrome, Right Leg | Open reduction, Salter’s Innominate Osteotomy, Takedown, Z-plasty |
| 2    | R    | F      | 44                     | 6                                                     | Bilateral DDH, Right Clubfoot, Left Vertical Talus | Takedown |
|      | L    |        | 27                     | 23                                                    | Bilateral DDH, Vertical Talus | Open reduction, Salter’s Inn. Osteotomy, Open reduction |
| 3    | R    | M      | 13                     | 21                                                    | Bilateral DDH, Vertical Talus | Open reduction, Salter’s Inn. Osteotomy, Open reduction |
| 4    | L    | F      | 9                      | 8                                                     | Left DDH, Bilateral Clubfoot | Open reduction |

DDH: Developmental Dysplasia of the Hip.

**Table 2. Ultrasound Measurements (Cases 1 and 4 are Unilateral, Data of Unaffected Patellae are also Included)**

| SIDE  | DPTD (mm) | DPCC (mm) | DPAP (mm) | PPTD (mm) | PPCC (mm) | PPAP (mm) | T (mm) | CC (mm) | AP (mm) |
|-------|-----------|-----------|-----------|-----------|-----------|-----------|--------|---------|---------|
| Case 1 | R         | 12.6      | 17.7      | 9.4       | 16.9      | 20.1      | 7.9    | 23.0    | 25.7    | 12.0    |
|       | L         |           |           |           |           |           |        |         |         |         |
| Case 2 | R         | 10.0      | 17.0      | 8.0       | 15.0      | 17.0      | 7.5    |         |         |         |
|       | L         | 10.0      | 19.3      | 7.6       | 9.4       | 21.0      | 5.6    |         |         |         |
| Case 3 | R         | 14.4      | 15.2      | 7.4       | 9.8       | 16.3      | 5.8    |         |         |         |
|       | L         | 8.0       | 16.4      | 7.2       | 10.7      | 16.1      | 7.2    |         |         |         |
| Case 4 | R         |           |           |           |           |           | 16.0   | 15.7    | 7.3     |         |
|       | L         | 8.0       | 14.5      | 7.0       | 7.0       | 14.0      | 6.6    |         |         |         |

AP, Anteroposterior; CC, Cranio-caudal; DP, Distal Patella Anteroposterior Dimension (mm); DPCC, Distal Patella Cranio-caudal Dimension (mm); DPTD, Distal Patella Transverse Dimension (mm); PPAP, Proximal Patella Anteroposterior Dimension (mm); PPCC, Proximal Patella Cranio-caudal Dimension (mm); PPTD, Proximal Patella Transverse Dimension (mm); T, Transverse.

**Table 3. Descriptive Statistics**

|                | N      | Minimum | Maximum | Mean   | Std. deviation |
|----------------|--------|---------|---------|--------|----------------|
| DPTD (mm)      | 6      | 8.0     | 14.0    | 10.333 | 2.3381         |
| DPCC (mm)      | 6      | 14.0    | 19.0    | 16.333 | 1.7512         |
| DPAP (mm)      | 6      | 7.0     | 9.0     | 7.500  | 0.8367         |
| PPTD (mm)      | 6      | 7.0     | 16.0    | 11.000 | 3.6332         |
| PPCC (mm)      | 6      | 14.0    | 21.0    | 17.333 | 2.6583         |
| PPAP (mm)      | 6      | 5.0     | 7.0     | 6.167  | 0.9832         |
This study would be the first report on the ultrasonographic assessment of the patella after Niebauer–King’s quadricepsplasty since 1960. Previously, disturbances of the growth of patella have been described; however, the effect of this surgical technique on the two halves of one patella has not been studied before. These are the strong parts of our study.

Small sample size, relatively short follow-up, different ages and evaluation times seem to be limitations. The ultrasonographic measurements were made in different periods because of the retrospective nature of the study, before patellar ossification was complete. Prospective cohort studies with the use of additional imaging techniques would provide more data about this rare pathology.

Niebauer–King’s quadricepsplasty is still an effective method in the treatment of congenital dislocation of the knee with extension contracture, seen in AMC.

**Ethics Committee Approval:** Ethics committee approval was received for this study from the Ethics Committee of Çukurova University, School of Medicine (Meeting No: 38, Decision No: 13, 2015).

**Informed Consent:** Informed consent was obtained from the patients.

**Author Contributions:** Concept - Ö.S.B.; Design - Ö.S.B.; Supervision - Ö.S.B.; Data Collection and/or Processing - S.S., Ö.F.E.; Literature Review - Ö.S.B., A.M.; Writing - Ö.S.B., A.M.; Critical Review - M.A.D., M.T.

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