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COMPARISON OF COMPUTER-ASSISTED ORTHO-SUV EXTERNAL FIXATORS WITH TRADITIONAL HYBRID EXTERNAL FIXATORS IN ADOLESCENTS WITH GENU RECURVATUM

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Purpose. To compare the computer-assisted Ortho-SUV ExFix with a traditional hybrid external fixator for the treatment of adolescents with genu recurvatum.

Material and methods. We retrospectively analyzed the examination findings and treatment results of 13 patients aged 13 to 17 years who had genu recurvatum of different etiologies in combination with crus shortening. The Ortho-SUV ExFix and a traditional hybrid external fixator were used in 5 patients each.

Results. The average time for deformity correction was 23 ± 3.8 days for the Ortho-SUV ExFix (group A) and 31 ± 4.5 days for the hybrid external fixator (group B). The fixation index (FI) was 49.8 days/cm for group A and 72.7 days/cm for group B. The posterior proximal tibia angle (aPPTA) reference value was 81° (77°–84°). aPPTA after the final correction was 81.8° ± 1.6° for group A and 85.2° ± 4.1° for group B.

Conclusions. The Ortho-SUV ExFix reduced the correction time by 8 days and FI by 22.9 days/cm relative to those of the hybrid external fixator. The genu recurvatum correction accuracy of the Ortho-SUV ExFix was superior to that of the hybrid external fixator.

Keywords: external fixation, deformity correction, genu recurvatum.

Introduction

Genu recurvatum is a very rare pathological condition of the lower limbs in children and adolescents [1–3]. This condition can be caused by changes in the bone (deformation), soft tissue (instability of the knee ligaments), or in both. Many authors agree that the main cause of tibial recurvatum deformation is the premature partial arrest of the proximal tibial physis [4–9]. The literature describes various methods for the correction of genu recurvatum deformation using extramedullary and transosseous fixation units and closing-wedge and opening-wedge osteotomy [10–15], but the accuracy or "quality" of correction achieved using these methods is not always good.

The aim of our study was to compare the results of the correction of genu recurvatum deformation achieved using a universal repositioning unit (URU) Ortho-ExFix with those achieved using a hybrid external fixation apparatus.

Material and Methods

We retrospectively analyzed the surgical treatment results of 13 patients aged 13–17 years (mean age, 15.4 years). The patients had genu recurvatum deformation of the proximal tibia combined with shortening of the limb (average, 3.4 ± 1.2 cm). In addition to genu recurvatum, four patients had a valgus deformity of the tibia (average, 8.2°). Six patients had undergone previous surgeries: three for congenital dislocation of the hip and three for treatment of Perthes disease.

We used clinical, radiographic, and computed tomographic diagnostic methods. In addition to standard teleradiographic projections, we performed stress teleradiography in the lateral projection, with the patient standing and maximum extension of the knee to provide reference joint positions during the subsequent deformity correction, and exclusion of ligament involvement in the formation of recurvation.

Surgical treatment included correction of the deformity and restoration of the limb length using the Ilizarov distraction osteosynthesis method. For correction of deformities, the URU Ortho-ExFix was used in five patients (group A) and an external hybrid fixation apparatus was used in eight patients (group B). After preoperative planning and determination of the level of the apex of the deformity by using reference lines and angles (RLN) [16], a closed corticotomy or open osteotomy, depending on the level of deformation, was performed, with subsequent correction of all components of the defect. When the apex of the deformation was at the level of the proximal tibial epimetaphysis, osteotomy was performed at a more distal location, with an additional transverse displacement of the distal fragment to restore normal RLN values.

For evaluation of the proximal tibial deformation correction status, the anatomical posterior proximal tibial angle (aPPTA) was used. The angle was measured in all patients before and after treatment. The reference value of aPPTA was 81° (range, 77–84°). The time period needed for correction of the deformity was also taken into account and the fixation index (FI) was calculated.

Results

Before treatment, all patients had excessive (hyperextension) range of motion in the knee joint. The degree of hyperextension depended on the degree of genu recurvatum. Deformation combined with ligament instability of the knee joint was found in five patients. The average aPPTA before treatment was 105.9 ± 5.9° (group A, 109.8 ± 5.6°; group B, 103.5 ± 5.0°). The average deformity correction time for the URU Ortho-ExFix was 23 ± 3.8 days and for the external fixation apparatus was 31 ± 4.5 days, which was associated with a need to rewire the apparatus step by step to eliminate each component of the deformation. The FI value for group A was 49.8 days/cm and for group B was 72.7 days/cm. The aPPTA after the final correction for group A was 81.8 ± 1.6°, which was in the acceptable reference value range, and that for group B was 85.2 ± 4.1°, which was beyond the acceptable value range.

The observation period depending on the patient ranged from 1 to 4 years. The length of the lower limb was restored by lengthening the femur. Valgus deformities in four patients were completely corrected. A summary of the patients' data before and after treatment is shown in Table 1.

The above methods of surgical treatment resulted in deformity correction in all studied patients. However, the use of the URU Ortho-ExFix reduced the correction time by an average of 8 days and reduced the FI value by 22.9 days/cm. The precision for correction of genu recurvatum tibial deformation using the URU Ortho-ExFix was greater than that achieved using the hybrid external fixation a pparatus.

Images of a patient treated using the URU Ortho-ExFix and external fixation apparatus for correction of lower leg recurvation deformities are shown in Figures 1 and 2.

Complications

For analysis of treatment complications, the classification of J. Caton (1991) was used as a guideline. This classification links complications to the results of the treatment and includes three categories. Category 1 complications are the most common (30.7%); these do not require additional interventions and do not affect the final treatment result. Category 1 complications include inflammatory changes in the soft tissue around transosseous elements and neurological deficits. In all cases, category 1 complications are cured by conservative treatment. Category 2 complications,

Table 1

Summary of patient data before and after treatment

aPPTA (Reference value range, 77–84°)				**Fixation (index, days/cm)**		**Average correction time (days)**	
I*		**S***		**I***	**S***	**I***	**S***
before	after	before	after	72.7	49.8	31 ± 4.5	23 ± 3.8
103.5 ± 5.0°	85.2 ± 4.1°	109.8 ± 5.6°	81.8 ± 1.6°				

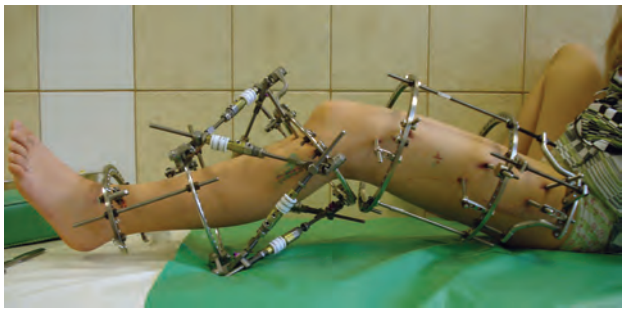
I*, Ilizarov apparatus was used for treatment; S*, URU Ortho-ExFix.

A

B

D

E



C

Figure 1. A 13-year-old child with tibial genu recurvatum who had previously undergone surgery for correction of hip displacement. Shown is the 4.0-cm shortening of her lower left limb due to femur and tibia–fibula shortening (*A*, *B*). Correction of the deformity (lengthening the femur) by using the URU Ortho-ExFix, (*C*). The aPPTA was 110° before treatment and 82° after treatment. Treatment results 18 months after surgery (*D*, *E*)

A

B

C

D

Figure 2. A 16-year-old child with valgus genu recurvate deformity of the left shin. The left lower limb is 2.0-cm short because of hip shortening (*A*). The child had previously undergone hip surgery for Perthes disease. The aPPTA was 103° before treatment (*B*), and was 87° after the correction (*D*). Correction of deformation performed using the hinge apparatus (*C*). The result of treatment after 18 months (*D*).

which require additional surgery but do not affect the treatment outcome, occurred in three patients. In the first of these three patients, a fracture of the femur regenerate required closed repositioning and continuation with plaster immobilization after dismantling of the apparatus. The second patient had a secondary valgus tibial deformity, which required surgical correction. In the third patient, premature consolidation of the fibula required re-osteotomy. There were no category 3 complications.

Discussion

Currently, the main method for correction of genu recurvatum deformation is to perform simultaneous corrective osteotomy with extramedullary osteosynthesis fixation followed by the use of external fixation devices to achieve gradual correction. The major disadvantages of "acute" open-wedge osteotomy corrections are the need to replace the defect with an autograft and the impossibility of restoring the limb length. For closed-wedge osteotomy, the main drawback is that additional shortening of the limb occurs.

The use of tension-distraction osteosynthesis not only eliminates the deformation but also restores the limb length; therefore, this method is mostly preferred [2–4, 8, 13, 15]. However, the use of hinges for the correction of deformations is a laborious process that requires reassembly of an apparatus several times and installation of hinges strictly on the apex of deformation, although in practice, it is virtually impossible to position the limb segment in such a way that the bone is strictly in the center of the support.

Published results [18,19] for comparisons of the accuracy of the correction of deformities achieved using the Ilizarov apparatus and modern devices based on computer navigation (hexapods) have shown that full corrections using the Ilizarov fixator have ranged from 26.8 to 79% and have been >91% for patients treated with hexapods depending on the complexity of the deformation. The results obtained in our study are consistent with those in the previous reports.

Conclusions

Use of the URU Ortho-ExFix for correction of genu recurvatum deformations reduced the correction time by an average of 8 days and reduced FI value by 22.9 days/cm. If we accept the reference aPPTA value (81°) as indicative of a 100% correction, then the main study group correction accuracy was 98% and that in the control group was 88.5%. Therefore, the accuracy of tibial genu recurvate deformation correction using the URU Ortho-ExFix was greater than that using the hybrid external fixation apparatus. However, the potential use of the URU Ortho-ExFix requires further analysis in patients with multiplanar deformities.

References

1. Bellicini C, Khoury JG. Correction of genu recurvatum secondary to Osgood-Schlatter disease: a case report. *Iowa Orthop J*. 2006;26:130-3.
2. Olerud C, Danckwardt-Lilliestrom G, Olerud S. Genu recurvatum caused by partial growth arrest of the proximal tibial physis: simultaneous correction and lengthening with physeal distraction. A report of two cases. *Arch Orthop Trauma Surg*. 1986;106(1):64-8.
3. Pappas AM, Anas P, Toczylowski HM Jr. Asymmetrical arrest of the proximal tibial physis and genu recurvatum deformity. *J Bone Joint Surg Am*. 1984;66(4):575-81.
4. Bowler JR, Mubarak SJ, Wenger DR. Tibial physeal closure and genu recurvatum after femoral fracture: occurrence without a tibial traction pin. *J Pediatr Orthop*. 1990;10(5):653-7.
5. Domzalski M, Mackenzie W. Growth arrest of the proximal tibial physis with recurvatum and valgus deformity of the knee. *Knee*. 2009;16(5):412-6. doi: 10.1016/j.knee.2009.01.008.
6. Laurà G, Berruto M, Bianchi M. Genu recurvatum following distal epiphysiodesis of the femur: X-ray evaluation and therapeutical approach. *Ital J Orthop Traumatol*. 1992;18(4):505-14.
7. Nathan ST, Parikh SN. Genu recurvatum after tibial tuberosity fracture. *Case Rep Orthop*. 2013;952978. doi: 10.1155/2013/952978.
8. Pennig D, Baranowski D. Genu recurvatum due to partial growth arrest of the proximal tibial physis: correction by callus distraction. Case report. *Arch Orthop Trauma Surg*. 1989;108(2):119-21.
9. Richards SW, Haddad FS, Hill RA. Case report. Post-traumatic tibial recurvatum: resolution with growth. *Ann R Coll Surg Engl*. 1998;80(6):419-21.
10. Beslikas T, Christodoulou A, Chytas A, et al. Genu Recurvatum Deformity in a Child due to Salter Harris Type V Fracture of the Proximal Tibial Physis Treated with High Tibial Dome Osteotomy. *Case Rep Orthop*. 2012;219231. doi: 10.1155/2012/219231.
11. Bowen JR, Morley DC, McInerny V, MacEwen GD. Treatment of genu recurvatum by proximal tibial closing-wedge/anterior displacement osteotomy. *Clin Orthop Relat Res*. 1983;(179):194-9.
12. Chen LC, Chan YS, Wang CJ. Opening-wedge osteotomy, allografting with dual buttress plate fixation for severe genu recurvatum caused by partial growth arrest of the proximal tibial physis: a case report. *J Orthop Trauma*. 2004;18(6):384-7.
13. Choi IH, Chung CY, Cho TJ, Park SS. Correction of genu recurvatum by the Ilizarov method. *J Bone Joint Surg Br*. 1999;81(5):769-74.
14. Lecuire F, Lerat JL, Bousquet G, Dejour H, Trillat A. The treatment of genu recurvatum (author's transl). *Rev Chir Orthop Reparatrice Appar Mot*. 1980;66(2):95-103.

15. Manohar Babu KV, Fassier F, Rendon JS, Saran N, Hamdy RC. Correction of proximal tibial recurvatum using the Ilizarov technique. *J Pediatr Orthop*. 2012;32(1):35-41.

16. Соломин Л.Н., Щепкина Е.А., Кулеш П.Н., и др. Определение референтных линий и углов длинных трубчатых костей: пособие для врачей. – СПб., 2010. - 48 с. [Solomin LN, Shchepkina EA, Kulesh PN, et al. Opredeleniye referentnykh liniy i uglov dlinnykh trubchatykh kostey: posobiye dlya vrachey. Saint-Petersburg, 2010. 48 p. (In Russ).]

17. Соломин Л.Н., Виленский В.А. Практическая классификация деформаций длинных трубчатых костей. // *Травматология и ортопедия России* (приложение). – 2008. – № 3. - С. 44. [Solomin LN, Vilensky VA. Practical classification of long bone deformities. *Traumatology and orthopedics of Russia* (supplement). 2008;(3):44. (In Russ).]

18. Соломин Л.Н., Щепкина Е.А., Виленский В.А., и др. Коррекция деформаций бедренной кости по Илизарову и основанным на компьютерной навигации аппаратом «Орто-СУВ». // *Травматология и ортопедия России*. – 2011. – № 3. - С. 32-39. [Solomin LN, Shchepkina EA, Vilensky VA, et al. Correction of femur deformities by Ilizarov method and by apparatus "Ortho-SUV" based on computer navigation. *Travmatologiya i ortopediy Rossii*. 2011;(3):32-39. (In Russ).]

19. Manner HM, Huebl M, Radler C, et al. Accuracy of complex lower-limb deformity correction with external fixation: a comparison of the Taylor Spatial Frame with the Ilizarov ring fixator. *J Child Orthop*. 2007;1(1):55-61. doi: 10.1007/s11832-006-0005-1.

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