Derotational osteotomy using simplified external fixator in management of idiopathic femoral intoeing

Ashraf Atef[1], MD; Mohamed El Ashhab[2], MD and Hossam M Gad[3], MD

1- Assistant Professor of orthopedics, Tanta University (main author)
2- Assistant Professor of Orthopedics, Banha University
3- Assistant Professor of Orthopedics, Kafr ElSheikh University

Corresponding author: Ashraf Atef, MD
Assistant Professor of orthopedics, Tanta University, Egypt
Main email: ashraf.mohamed@med.tanta.edu.eg
2nd email: ashraf19970@yahoo.com
Address: Egypt- Tanta – Tanta University – Faculty of medicine- Orthopedic department
Tel: 00201000630825

Abstract

Background: Idiopathic persistent femoral anteversion is a common cause of intoeing causing walking difficulties with painful hip and knee joints. This study presents if the proximal femoral derotational osteotomy using a simplified Ilizarov external fixator effective in idiopathic intoeing

Patients and methods: Thirty-seven limbs in 21 children underwent proximal femoral derotational osteotomy in the period between January 2014 and June 2017. The deformity was bilateral in 16 children while one side was affected in five cases. There were nine boys and twelve girls with a mean age of 9.3years. Both limbs were operated at the same time in all bilateral cases. The technique in the present study was done using two Ilizarov arches fixed to the proximal part of the femur with the osteotomy performed percutaneously using multiple drills an osteotome technique. Children were nursed in a wheelchair for the first two weeks postoperative after which partial weight-bearing was allowed using two crutches. During follow up, children were evaluated according to the Staheli rotational profile and the improvement of their preoperative symptoms.

Results: All cases were followed for at least two years. Complete consolidation of the osteotomy site was obtained within an average of 8.8 weeks. The internal rotation degree was decreased significantly from an average of 82.4 to 45.4 postoperatively. The main complication was superficial pin tract infection in ten limbs (23.8%)

Conclusion: The less invasive derotation proximal femoral osteotomy technique, fixed by the two arches system is applicable in the management of idiopathic femoral ante-version.

Keywords: Intoeing, femoral anteversion, osteotomy, external fixator.

Introduction:

Pediatric rotational lower limb deformities are common and usually self-limited. The Ante-version angle of the femur is the angle between the axis of the femoral neck and the axis of the distal condyles at the most posterior points. There is a gradual decrease in femoral anteversion in the first decade of life with the improvement of the gait pattern [1,2]. Excessive femoral ante-version can be complicated by external rotation of the tibia in older children. This mismatch can lead to hip and knee problems, difficulties with running, and psychological problems because of the abnormal gait [3-7].

The most common cause of intoeing is cerebral palsy. Idiopathic persistent femoral anteversion is another cause of intoeing[8,9]. To our knowledge, few published articles are searching for surgical treatment of idiopathic type.

Femoral osteotomies were described in the literature either proximal or distal with the benefits and complications of either level[9-12]. Also, many fixation methods have been used including plates and interlocking intramedullary nails[13,15,16-20]. Another method of fixation is the external fixator [15,21-23].

Patients and methods

The proximal diaphyseal femoral derotational osteotomy was performed in 21 patients (37 limbs). The clinical and radiological data of the children who underwent osteotomy between January 2014 and June 2017 were reviewed in this prospective study. All procedures have been performed under the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. Data were collected including age, gender, operative time, and time to complete consolidation and frame removal. The deformity was bilateral in 16 children, left side in three cases while the right side was affected in two cases. There were nine boys and twelve girls of the mean age of 9.3years (range 7-11 years). The mean weight was 36.4 kg (range 25 – 45 kg). Both limbs were operated at the same time in all bilateral cases.

Presenting complaints were documented including hip or knee pain and frequent falling. Also, the pre and postoperative internal rotation degrees were collected and analyzed (Table 1). The rotational profile of lower limbs was carefully assessed according to Staheli [24] to determine the level of intoeing. Medial rotation more than 70° suggests a diagnosis of excessive femoral anteversion. The degree of femoral anteversion angle was confirmed by computed tomography (CT) scan. Preoperatively the child was examined to exclude neuromuscular deficits. Videotaping of the gait was recorded for analysis, documentation, and postoperative comparison in each case.

Inclusion criteria were 1) children above the age of seven years 2) persistent idiopathic intoeing with a femoral internal rotation angle above 70 degrees clinically and 30 degrees on CT scan.

The exclusion criteria were 1) children younger than seven years. 2) internal rotation of less than 70 degrees. 3) history of major lower limb skeletal trauma or orthopedic procedures. 4) Patients with asymptomatic

femoral anteversion. 5) intoeing due to neuromuscular disorders.

Table 1: Demographic data of the operated children

Age		7-11 average 9.3y
weight		25-45 average 36.4 kg
Gender	Male	9(42.8%)
	Female	11(57.2%)
Side effect	L	19(51.4%)
	R	18(48.6%)
Pre-anteversion CT angle		30-40 (37.4) degrees
Operative time		35-55 (45) minutes
Time of fixation		8-12 (8.8) wks

Operative technique

Prophylactic antibiotics were given at induction of anesthesia. The patients were operated supine on a translucent operating table. Intraoperative radiography was a must in all cases. The technique in the present study was done using two arches of the Ilizarov frame components fixed to the proximal part of the femur with the osteotomy performed percutaneously using multiple drills an osteotome technique.

Under the image intensifier, the limb was internally rotated to visualize the true antero-posterior view of the hip joint. The first half pin was inserted at the level of the lesser trochanter using the standard technique of half pin insertion (pre-drilling using a sharp drill bit then manual insertion of a 5-mm half pin). The limb was then externally rotated to bring the knee joint into the antero-posterior view (patella facing forward). A second pin was inserted distal to the proposed level of the osteotomy. Now the two pins subtend an angle equal to the desired angle of derotation, as visualized axially, (Fig. 1a). To each pin, a medium-sized arch from the Ilizarov frame components was attached. The arches were vertically oriented to allow rotation without creating any angular or translation deformity. To each arch, a second pin was attached. Percutaneous multiple drill holes osteotomy was performed through a one-cm incision. Holding the two arches, the distal one was internally rotated, under image intensifier control, to bring the first two pins in the target derotation degree (fig. 1b). Then the two arches were connected by threaded rods to maintain the new position. The correction was checked by the image in the antero-posterior and cross-table lateral positions. Clinically, the limb was examined for the hip rotational range of motion and compared to the preoperative findings. Radiologically, the correction was confirmed under fluoroscopy, and then the fixation was augmented by a third pin in each bone segment depending on the size of the child (fig.1c). The knee was manipulated to full flexion to relieve the tethering effect of the pins traversing the iliotibial tract.

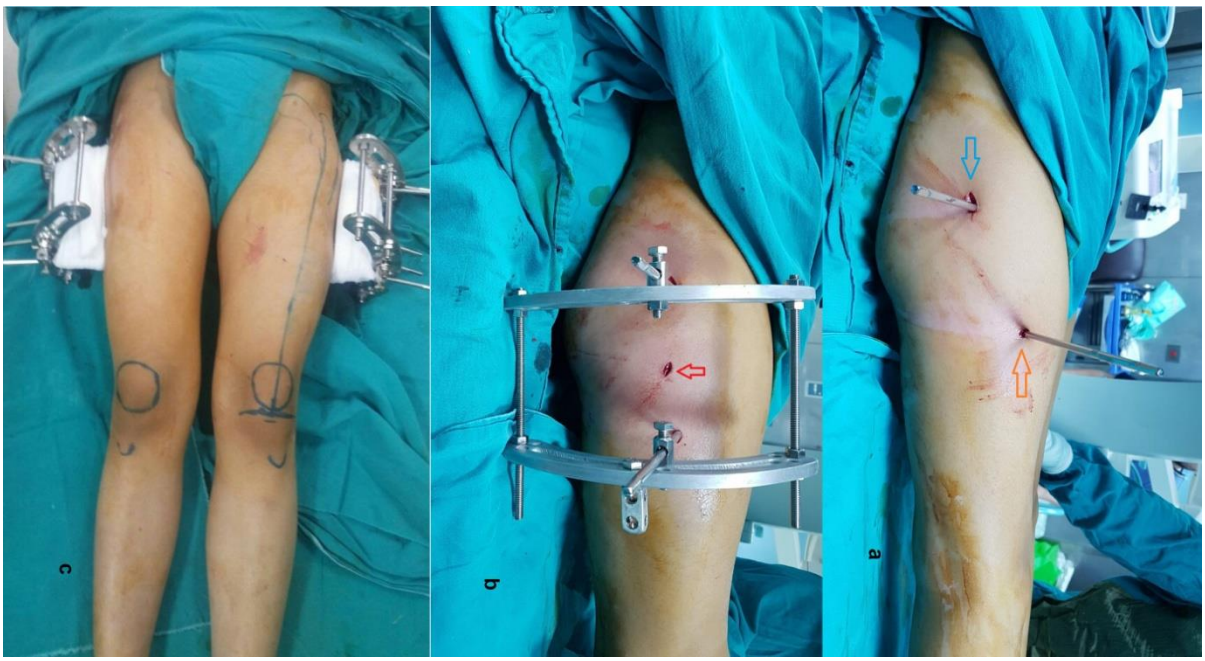

Figure 1: intraoperative steps by a) the limb was internally rotated to visualize the true antero-posterior view of the hip joint. The first half pin was inserted at the level of the lesser trochanter (orange arrow). The limb was then externally rotated to bring the knee joint into the antero-posterior view (patella facing forward). A second pin was inserted distal to the proposed level of the osteotomy (blue arrow). Now the two pins subtend an angle equal to the desired angle of derotation, as visualized axially. b) percutaneous osteotomy is performed (red arrow) and the 2 half pins are realigned to the corrected degree and connected. c) the frame construction is then augmented by inserting 1 or 2 more half pins to each arch.

Postoperative regimen:

The usual hospital stay was between two and five days. Children were nursed in a wheelchair for the first two weeks postoperative with immediate postoperative physiotherapy to mobilize the knees and hips, when postoperative pain settles down, after which partial weight-bearing was allowed as tolerated. Follow up radiographs were obtained at the first visit after two weeks then every one month until complete consolidation of the osteotomy site. In the first follow up visit the child was examined clinically while supine and standing for the new rotational profile and compared to the preoperative one.

After complete radiological bone consolidation, the fixator was removed under sedation as an outpatient procedure. There was no need to apply cast after frame removal. Cases were then followed every month for the first six months and every three months, thereafter, up to two years.

During follow up, children were evaluated according to the Staheli rotational profile and the improvement of their preoperative presenting symptoms. Patients' complaint was determined according to the frequency of falling and the degree of pain of the knee and hip. This was graded from 1 to 10 for each of the three complaints with grade one less falling and no pain of the hip and knee joints which increases gradually according to the rate of falling and severity of the pain.

Statistical analysis:

The collected data were tabulated and analyzed using SPSS version 22 software (SpssInc, Chicago, ILL Company). Quantitative data were tested for normality using the Kolmogorov-Smirnov test, if p-value >0.05 data were considered normally distributed. Categorical data were presented as numbers and percentages while quantitative data were expressed as mean ±standard deviation and range. Man Whitney U test, Wilcoxon ranked test, and Spearman's correlation coefficient was used as tests of significance for non-parametric data. The accepted level of significance in this work was stated at 0.05 (P<0.05 was considered significant).

Results:

All cases were followed for at least two years. The mean operative time was 46 minutes per limb (35–45 minutes) with less than 50 cc blood loss. Complete consolidation of the osteotomy site was obtained within an average of 8.8 weeks (8–12 weeks) postoperative. The internal rotation degree was decreased significantly from an average of 82.4 preoperatively to 45.4 postoperatively (P<0.05) (table 2).

According to the patient complaint grading, the falling frequency was significantly decreased from an average of 6.5 points to 2.6 (P<0.05). Both hip and knee pain was improved significantly, from average 5.8±2.5 and 4.2±2.9 points to 2.6±0.75 and 3±2.2 respectively (P<0.05). Satisfactory results were considered when the sum of the three complaints was less than 10 of 30 points. Although the general average functional results were satisfactory (average 8.2±2.8), 3 cases with 3 limbs (8.1%) experienced unsatisfactory functional results with the persistence of the preoperative knee pain.

Table 2: Analysis of the results

	pre	post	Paired t-test
Internal rotation (degrees)	82.4±2.9	45.4±3.2	<0. 05
Clinical falling (points)	6.5±2.3	2.6±0.75	<0.05
Clinical hip pain (points)	5.8±2.5	2.6±0.75	<0.05
Clinical knee pain (points)	4.2±2.9	3±2.2	<0.05
Total clinical score (points)	16.2±1.4	8.2±2.8	<0.05

Bodyweight was negatively correlated (inversely associated) with total score postoperatively. Females had higher post-operative scores (9.2±3.3) compared with males (7.42±2.1) and these findings were of no statistically significant importance (P>0.05) (table 3).

The main complication was superficial pin tract infection in ten limbs (23.8%) which resolved completely after oral antibiotics. Figures 2,3&4 show one case presentation.

Table 3: the effect of the weight and gender on the end results:

		Total score post	Significance
Weight		rho=0.1-	>0.05
Gender	male	7.42±2.1	>0.05
	female	9.2±3.3	

Figure 2: Eight years old girl with bilateral femoral anteversion with internal rotation of 80 degrees on the right side and 85 degrees on the left side. She was complaining of frequent falling with a painful knee and hip joints.

Figure 3: Radiological and clinical follow-up showing uniting bilateral proximal shaft derotational osteotomy fixed by the external fixator.

Figure 4: Complete consolidation of the osteotomy site with an improvement of the internal rotation to 45 degrees both sided. The child and her parents are satisfied by the results with relief of the knee and hip pain and lessening of falling.

Discussion

Excessive femoral anteversion remains the most common cause of persistent intoeing gait in children. Staheli rotational profile [24] is the most common reference for the assessment of intoeing. It is used to differentiate clinically between femoral ante-version, tibial torsion, and metatarsus adductus. Suspected cases of increased femoral anteversion can be further assessed with a CT scan to measure the femoral ante-version degree and tibial torsion. Conservative follows up is the main line of treatment of femoral ante-version because of its known natural history to correct spontaneously [5,6]. However, torsional abnormalities can cause discomfort in the form of frequent falling, hip discomfort, or anterior knee pain [25-27]. In some complicated cases, intoeing is compensated by lateral tibial torsion without a change in femoral ante-version causing problematic patellar mal-tracking and anterior knee pain [7]. Conservative management is ineffective for those patients and surgery is essential to prevent more pathology. Surgical correction can be performed using derotation femoral osteotomy at different levels with many methods of fixation.

Either proximal or distal levels of the femur have been used for derotation osteotomy. The proximal osteotomy has the biomechanical advantage of being closer to the deformity, whereas the distal approach is easier and the use of tourniquets can reduce blood loss [9-12]. We used in the present study proximal osteotomy because of its proximity to the origin of the deformity and the more or less simplicity of our two arches frame which makes it easy to apply to the proximal thigh.

Many methods can be used in stabilization of the osteotomy site including plating, intramedullary nailing, and external fixators. Generally, the ideal method of fixation is the one that can be applied easily with minimal incisions, maintains rigid fixation, and allows early mobilization with no need for another operation to remove hardware. Intramedullary nailing has the advantage of high primary stability which allows early weight-bearing with minimal cosmetic incisions [16-20]. On the other hand, nailing in children has the problem of femoral head avascular necrosis because of the entry point. Recent nail designs allow a more lateral entry point onto the greater trochanter to decrease the risk of avascular necrosis [20].

Similarly, many authors recommend the use of plate fixation, which has the problems of a bigger incision and lesser stability [14,15]. Literature recommended intramedullary nail in diaphyseal derotational osteotomy while plating is used when osteotomy is either distal or proximal metaphyseal. The shared problem of the above mentioned two methods is the need for another operation to remove [28] and the inability to re-adjust the correction postoperatively in case the correction was not acceptable.

Mylle and coworkers [15] compared three methods of fixation (wiring, plating, and external fixation) after derotational osteotomy at different levels. They recommended supracondylar osteotomy fixed by external fixator because of its fewer complications and more stability.

Various types of external fixators are available that can generally be classified into two groups; ring fixators and monolateral fixators. Both fixator types provide mechanical stability and can be used safely in deformity correction. Skiak and coworkers [22] recommended the use of distal femoral derotational osteotomy fixed by a monolateral external fixator. They reported the advantages of stable fixation, early ambulation, ease of alignment, small incisions, and low device cost. But, they extended the fixation across the knee to augment the distal fixation with the reported risk of postoperative knee stiffness. On the other hand, Moens et al [23] used the Ilizarov arches in fixation of distal diaphyseal femoral osteotomies with no need to fix the knee.

In our study, we used diaphyseal osteotomy as proximal as possible near the origin of the pathology which is the femoral neck. We used femoral arches components of the Ilizarov frame to fix the osteotomy with two to three half pins at each site at different planes to increase the stability of the frame which allows early ambulation within few days. Additionally, the osteotomy was performed percutaneously through the minimal incision using multiple drill holes technique. The use of this low-energy osteotomy technique enhances the quality and time of bony union because of its low thermal effect. Our results are promising with the consolidation of the osteotomy site in all cases within an average of 8.8 weeks. Most children (91.9%) experienced satisfactory relief of the pre-operative symptoms (frequent falling, painful hip, and knee discomfort). The shared factor in the three cases with unsatisfactory functional results (residual knee pain) was the increased weight.

The use of the two arches construct in the current study has the benefits of the easiness to apply through minimal incisions, trivial blood loss, early ambulation, and the ability to remove in the outpatient clinic under light sedation. Another important advantage of the present technique is the ability to readjust the frame to correct any residual deformity and this is not allowed by any other method of fixation. However, there are some drawbacks to the present technique including inconvenience due to bulky frames. However, this issue was overcome by taking enough time with the patient to discuss the benefits and drawbacks of the external fixation and how to deal with potential complications. Pin tract infection is another complication that was found in ten limbs (27 %) which was treated by oral antibiotics and educating the parents on how to clean the pin sites.

The limitation of this study is the lack of comparison between the proximal and distal femoral osteotomies and the comparison with other fixation alternatives in the management of femoral intoeing. Another drawback is the lack of objective postoperative measurements of femoral anteversion angles with CT scans and gait lab analysis which should be considered for future studies.

Conclusion

The presented less invasive derotation proximal femoral osteotomy technique, fixed by the two arches system is versatile and effective in the management of idiopathic persistent femoral ante-version.

Conflict of Interest: The authors declare that they have no conflict of interest.
Funding: There is no funding source.

All procedures followed were under the ethical standards of the responsible local institutional committee on human experimentation. Informed consent was taken from the child's caregivers.

References

1. Lincoln TL, Suen PW. (2003) Common rotational variations in children. J Am AcadOrthop Surg.;11:312–320.
2. Ryan DJ (2001) Intoeing: a developmental norm. OrthopNurs 20(2), 13–18.
3. Cahuzac JP, Vardon D, Sales de Gauzy J (1993) Deformities of the lower limbs in the frontal plane in children. Ann Pediatr (Paris); 40:230–236.
4. Staheli LT (1994) Rotational problems in children. Instr Course Lect 43, 199–209.
5. Fabry G, MacEwen GD, Shands AR (1973) Torsion of the femur: a follow-up study in normal and abnormal conditions. J Bone Joint Surg;53A:1726-38.
6. Thackeray C, Beeson P (1996) Is in-toeing gait a developmental stage? The Foot 6, 19–24.
7. Fabry G (1997) Normal and abnormal torsional development of the lower extremities. ActaOrthop Belg 63(4), 229–232.
8. Kim H, Aiona M, Sussman M. (2005) Recurrence after femoral derotational osteotomy in cerebral palsy. J PediatrOrthop; 25:739–743.
9. Edmonds EW, Fuller CB, Jeffords ME, et al. Femoral derotational osteotomy level does not affect resulting torsion. J Exp Orthop. 2020;7(1):9. Published 2020 Mar 4. doi:10.1186/s40634-020-00227-9
10. Nelitz M. (2018). Femoral Derotational Osteotomies. Current reviews in musculoskeletal medicine, 11(2), 272–279.
11. Kay RM, Rethlefsen SA, Hale JM, Skaggs DL, Tolo VT. (2003) Comparison of proximal and distal rotational femoral osteotomy in children with cerebral palsy. J Pediatr Orthop; 23:150–154.
12. Niklasch M, Boyer ER, Novacheck T, Dreher T, Schwartz M (2018) Proximal versus distal femoral derotation osteotomy in bilateral cerebral palsy. Dev Med Child Neurol. Oct;60(10):1033-1037
13. Davids JR et al. (2014) Surgical management of persistent Intoeing gait due to increased internal tibial torsion in children. J Pediatr Orthop 34(4), 467–473.
14. Haefeli M, Huber H, Dierauer S (2010) Fixation of subtrochanteric extending/derotational femoral osteotomies with the locking compression plate in ambulatory neuro-orthopaedic patients. J Child Orthop.;4:423–428.
15. Mylle J, Lammens J, Fabry G. (1993) Derotation osteotomy to correct rotational deformities of the lower extremities in children. A comparison of three methods.Acta Orthop Belg.;59(3):287-92.
16. Kempf I, Dagrenat D, Kloos M. (1990) Correction osteotomy and stabilization with the interlocking nail. Unfallchirurg; 93:499–505.
17. Iobst CA, Ansari A. Femoral Derotational Osteotomy Using a Modified Intramedullary Nail Technique. Tech Orthop. 2018;33(4):267-270. doi:10.1097/BTO.0000000000000261
18. Gordon JE, Pappademos PC, Schoenecker PL, et al. (2005) Diaphyseal Derotational osteotomy with intramedullary fixation for correction of excessive femoral anteversion in children. J Pediatr Orthop.;25:548–553.
19. Pailhe R, Bedes L, Sales de Gauzy J, et al. (2014) Derotational femoral osteotomy technique with locking nail fixation for adolescent femoral Antetorsion: surgical technique and preliminary study. J Pediatr Orthop B.;23:523–528
20. Stevens PM, Gaffney CJ, Fillerup H. (2016) Percutaneous rotational osteotomy of the femur utilizing an intramedullary rod. Strategies Trauma Limb Reconstr.;11:129–134.
21. Morasiewicz P, Filipiak J, Krysztoforski K, Dragan S. Clinical factors affecting lower limb torsional deformities treatment with the Ilizarov method. Orthop Traumatol Surg Res. 2014;100(6):631-636. doi:10.1016/j.otsr.2014.03.019
22. Skiak E, Karakasli A, Basci O, et al.(2015) Distal femoral derotational osteotomy with external fixation for correction of excessive femoral anteversion in patients with cerebral palsy. J Pediatr Orthop B.; 24:425–432.
23. Moens P, Lammens J, Molenaers G, Fabry G. (1995) Femoral derotation for increased hip anteversion. A new surgical technique with a modified Ilizarov frame. J Bone Joint' Surg Br; 77:107–109.
24. Staheli LT et al. (1985) Lower-extremity rotational problems in children. Normal values to guide management. J Bone Joint Surg Am 67(1), 39–47
25. Stambough JB, Davis L, Szymanski DA, Smith JC, Schoenecker PL, Gordon JE. Knee Pain and Activity Outcomes After Femoral Derotation Osteotomy for Excessive Femoral Anteversion. J Pediatr Orthop. 2018;38(10):503-509. doi:10.1097/BPO.0000000000000874
26. Stevens PM et al. (2014) Success of torsional correction surgery after failed surgeries for patellofemoral pain and instability. Strategies Trauma Limb Reconstr 9(1), 5–12.
27. MacWilliamsa BA, McMulkinc ML, Davisd R B, Westberryd DE, Bairdc GO, Stevensb PM (2016) Biomechanical changes associated with femoral derotational osteotomy. Gait & Posture 49. 202–206
28. Svenningsen S et al. (1989) Osteotomy for femoral anteversion. Complications in 95 children. ActaOrthop Scand 60(4), 401–405.