Autologous Fibular Strut Graft in Opening Wedge Valgus Tibia Osteotomy in Children with Genu Varum

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Abstract

Background: Genu varum is considered one of the most frequent lower-limb misalignments linked to pain and dysfunction. Open and closed high tibial osteotomies are the most prevalent methods of genu varum correction. **Objectives:** To find a better, cheap, and much more comfortable method of maintaining the open wedge of valgus tibial osteotomy for genu varum deformity without adding cost, ugly scar, or a re-operation for the removal of the implant. **Methods:** Eighteen patients with clinical and radiological genu varum from the orthopedic surgery department, Zagazig University Hospital, and Menoufia University Hospital between September 2020 and August 2021 were included in this study. Consequently, these patients had opening wedge osteotomy of the proximal tibia using fibular strut graft maintaining the wedge and then followed up for six months. Preoperative variables comprised: age, gender, Body Mass Index (BMI), patient selection, patient and parents counseling, patient evaluation clinically and radiologically, and preoperative preparation. Intraoperative variables comprised: Fibular osteotomy, Tibial osteotomy, the degree of osteotomy, Fasciotomy, and Graft Fixation. Postoperative variables included: A postoperative assessment at each visit via clinical examination, clinical scores, and radiographic evaluation by standard radiographs. **Results:** There was a statistically significant change in the tibiofemoral angle (significantly decreased postoperatively) and medial proximal tibial angle (significantly increased postoperatively). According to the mechanical axis correction and Schoenecker's criteria, the final results were good in 16 cases (88.90%), fair in one case (5.55%), and poor in one (5.55%). **Conclusion:** we concluded that autologous fibular strut graft is an excellent graft for maintaining open wedge medial tibial osteotomy in pediatrics genu varum correction.

KeyWords: Valgus, Tibia, Osteotomy, Orthopedics.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Introduction

Bowlegs is referred to in Latin as genu varum. It is among the most prevalent lower limb misalignments linked with dysfunction. Nevertheless, little attention has been made to limb position and muscle activity in individuals with genu varum while executing tasks [1].

This condition can occur at any age, from childhood to maturity, and has many reasons. The patients may display lateral knee thrust and a waddling gait as the disease progresses. There may be a correlation between in-toeing and secondary hip and ankle consequences [2].

It has a physiologic as well as pathologic etiology. For parents, this is a critical issue. While physiologic genu varum is self-limiting and normally requires only clinical follow-up, the pathologic genu varum frequently progresses over time, contributing to mechanical lower limb difficulties and joint complications [2].

The physiologic form continues to be the most prevalent worldwide, whereas nutritional rickets is the second most prevalent cause. Other causes are infrequent or even exceedingly rare. Genu varum might even occur in conjunction with systemic disorders, including achondroplasia, vitamin D-resistant rickets, renal osteodystrophy, and defective bone formation [1].

Interventional indications are frequently ambiguous. Numerous surgical techniques for treating the pathologic genu varum have been characterized, such as proximal tibial osteotomy, hemi epiphysiodesis, asymmetric physeal distraction, as well as medial tibial plateau elevation. The primary objective of treatment is to reestablish the limb's mechanical axis [3].

Open and closed high tibial osteotomies are the most often performed procedures to treat genu varum. Numerous techniques have been utilized to maintain medial tibial open wedge osteotomy. The iliac crest graft, orthopedic plates, screws, and artificial bone substitutes are only a few of these [4].

These include surgeries performed at locations other than the surgical site, potentially introducing another source of pain, discomfort, unpleasant scarring, and risk of infection. On the other hand, bone substitutes are costly, creating an additional burden in resource-constrained environments. If plates and screws are used, further surgery will be required to remove the implant [5].

The aim of this research was to develop an efficient, cost-effective, and constructive means of maintaining the open wedge of valgus tibial osteotomy for genu varum deformity without additional costs, an unpleasant scar, or requiring a re-operation to remove the implants.

Patients and Methods

Patients:

Eighteen patients with clinical and radiological genu varum from the orthopedic surgery department, Zagazig University Hospital, and Menoufia University Hospital between September 2020 and August 2021 were recruited in this study. Consequently, these patients had opening wedge osteotomy of the proximal tibia using fibular strut graft maintaining the wedge and then followed up for six months. The mean age was 4.69 ± 2.57 years (range, 3 – 12years). Inclusion criteria comprised: children and young adults of both sexes aging 3 to 12 years with an intact vascular status of the affected limb and available follow-up records of at least six months postoperatively. Exclusion criteria comprised: patients with severe cognitive dysfunction and absence of independent walking capability before surgery, implants, or surgical approach other than those specified in this study

Methods:

Initially, an intravenous antibiotic was administered one hour before the procedure. Under general anesthesia, the patient was positioned supine with a tourniquet at the thigh; a vertical incision on the lateral fibula was used to harvest the fibular graft at about 5 to 10cm below the fibular neck (Figure 1). A strut of about 3cm to 5cm was harvested. An elliptical incision on the medial aspect of the proximal tibial was used the approach the osteotomy. A transverse cut parallel to the joint line was made (Figure 2) and opened until the deformity was over-corrected to 10 degrees of valgus for children less than 12 years of age with much growth still left and 5 degrees of valgus from older children.

This cut also maintained the mechanical axis of the lower limb. The fibular strut was either placed transversely into the cut or vertically, depending on the size of the open wedge (Figure 3). The wound was then closed by absorbable sutures, and the site of the fibular harvest was also sutured after ensuring that more bone would not be needed.

A postoperative evaluation at each visit was done via clinical examination, clinical scores, and radiographic assessment by standard radiographs (Plain X-ray anteroposterior and lateral views).

Figure 1. Photographic pictures showing fibular incision.

Figure 2. Photographic pictures showing tibial osteotomy.

Figure 3. Photographic pictures showing fibular graft maintaining the wedge open.

Assessment:

Preoperative variables comprised: age, gender, Body Mass Index (BMI), patient selection, patient and parents counseling, patient evaluation clinically and radiologically, and preoperative preparation. Intraoperative variables comprised: Fibular osteotomy, Tibial osteotomy, the degree of osteotomy, Fasciotomy, and Graft Fixation. Postoperative variables included: evaluation at each visit via clinical examination, clinical scores, and radiographic assessment by standard radiographs (Plain X-ray anteroposterior and lateral views).

Statistical analysis:

The collected data were tabulated and analyzed by SPSS version 20 (statistical package for the social science software). Quantitative data were expressed as mean and standard deviation (X ±SD), while qualitative data were expressed as numbers and percentages (No & %) and analyzed using the chi-square test. For comparison between the normally distributed quantitative data at the interval for the same group, a paired-samples t-test was applied. In contrast, Wilcoxon signed-rank test was applied for non-normally distributed data. P-value≤ 0.05 was considered statistically significant, and P-value ≤ 0.001 to be highly statistically significant.

Results

Table 1 demonstrates the demographic data of the studied patients. Age ranged from 3 to 12 years with a mean of 4.96 years. Females represented 38.89%, while males 61.11%. The distribution of the studied patients according to the cause and laterality is shown in Table 2. Post rickets deformity occurred in 72.22%, while 55.55% of patients had a bilateral deformity. Table 2 illustrates the distribution of the participants according to the mode of fixation. Among 28 limbs, 60.72% had been fixed by a cast, 25% underwent cast and K wires, 7.14% had cast and staples, and 7.14% had plate fixation. Table 3 shows the pre and postoperative change in the angle of deformity among the participants. There was a statistically significant change in the tibiofemoral angle (significantly decreased postoperatively) and medial proximal tibial angle (significantly increased postoperatively). The preoperative tibiofemoral angle was corrected from 26.89 ± 6.11 to 9.01 ± 1.28 postoperative, and the preoperative medial proximal tibial angle was corrected from 76.39 ± 3.15 degrees to 94.78 ± 2.56 postoperative. 88.90% had no complications, while 11.10% had postoperative complications in form of superficial infection and residual deformity, as demonstrated in Table 2. Overall, according to the mechanical axis correction and Schoenecker's criteria, the final results of the studied patients were good in 16 cases (88.90%), fair in one case (5.55%), and poor in one (5.55%). (Table 2). Table 4 demonstrates the relation between the findings and demographic data. There was a statistically non-significant relation between the findings and age or gender. The connection between the findings and the mode of fixation is shown in Table 5. Beneficial results were found regarding the cast and fibular grafts. There was a statistically non-significant relation between the findings and the cause of deformity (Table 6).

Table 1. Demographics of the studied patients

Parameter	N=18
Age	
Mean ± SD	4.69 ± 2.57
Min – Max	3 - 12
Gender	
Female	7 (38.89%)
Male	11 (61.11%)

Table 2. The distribution of the studied patients according to the cause laterality, mode of fixation, complications, and outcome.

Parameter	N=18
Cause	
Post rickets	13 (72.22%)
Blount disease	5 (27.78%)
Laterality	
Unilateral	8 (44.44%)
Bilateral	10 (55.56%)
Mode	
Cast	17 (60.72%)
Cast and K wires	7 (25%)
Cast and staples	2 (7.14%)
Plate	2 (7.14%)
Complications	
No	16 (88.90%)
Superficial infection	1 (5.55%)
Residual deformity	1 (5.55%)
Outcome	
Good	16 (88.90%)
Fair	1 (5.55%)
Poor	1 (5.55%)

Table 3. The change in the angle of deformity among the studied patients pre and postoperatively.

Angle of deformity	Time		Test	
	Preoperative	Postoperative	t	p
Tibiofemoral angle (TFA):				
Mean ± SD	26.89 ± 6.11	9.01 ± 1.28		
Min - Max	16 – 35	7 – 11	11.56	<0.001**
Medial proximal angle (MPTA):				
Mean ± SD	76.39 ± 3.15	94.78 ± 2.56	-21.19	<0.001**
Min - Max	69 – 84	92 – 100		

**p≤ 0.001 is statistically highly significant.

Table 4. The relation between the outcome and demographic data of the studied patients.

Angle of deformity	Outcome		Test	
	GoodN=16	Fair and Poor N=2	t/χ^2	p
Age:				
Mean ± SD	8.94 ± 1.34	9.5 ± 0.707	-0.577	0.564
Min - Max	3 – 12	3 - 12		
Gender				
Female	7 (43.8)	0 (50)		
Male	9 (65.2)	2 (50)	Fisher	0.245

χ^2=Chi square test, **t=** independent sample t-test.

Table 5. The relation between the outcome and mode of fixation.

Parameter	Outcome			Test	
	Good N=16 (88.90%)	Fair N=1 (5.55%)	Poor N=1 (5.55%)	χ^2	p
Mode:					
Cast	9 (56.3%)	1 (100%)	0 (0.0%)		
Cast and K wires	4 (25.0%)	0 (0.0%)	0 (0.0%)		
Cast and staples	2 (12.5%)	0 (0.0%)	0 (0.0%)	3.565	0.161
Plate	1 (6.3%	0 (0.0%)	1 (100%)		

χ^2Chi square test.

Table 6. The relation between the outcome and cause of the deformity.

Cause of deformity	Outcome			Test	
	Good N=16 (88.90%)	Fair N=1 (5.55%)	Poor N=1 (5.55%)	χ^2	p
Post rickets	12 (75.0%)	0 (0.0%)	1 (100%)	Fisher	0.218
Blount	4 (25.0%)	1 (100%)	0 (0.0%)		

χ^2Chi square test.

Figure 4. Clinical case, A five-year-old female,standing anteroposterior radiograph at presentation shows post rickets genu varum, Standing AP radiograph three months post-operative showing union and maintained correction, Standing AP radiograph at eight-month post-operative visit showing good alignment and complete union, clinically the patient was pain-free and parents satisfied with results.

Discussion

Genu varum is a varus deformity characterized by outward knee bending. The lower leg is inclined inward medially concerning the thigh's axis, giving the limb the appearance of an archer's bow. Lower limb bones (femur and tibia) usually engage medial angulation [6].

The hip-knee-ankle angle, which is an angle between the femoral mechanical axis and the center of the ankle joint on protectional radiography, can determine the degree of varus or valgus deformity. It is usually between 1.0° and 1.5° of varus in adults. Children's normal ranges differ from adults [7].

Cruz discovered that while the idiopathic presentation was a typical anatomical variation in early childhood, no therapy was necessary. The treatment was required when it lasted more than three and a half years. When rickets was the reason for unilateral presentation or gradual worsening of the curvature, the necessary action was to treat the constitutional illness and inform the caregiver not to put the kid on his feet [8].

It was enough to provide treatment in many situations; however, splints could help enhance the recovery. Surgery was the only permanent treatment when a deformity developed in an older patient due to an accident or work; however, orthopedic bracing could give temporary relief [9].

The state-of-the-art therapy for infantile tibia vara, according to Ferrick, was a metaphyseal osteotomy with sharp correction and internal or external fixation. A proximal tibial metaphyseal osteotomy could be used to treat acute angular and rotational deformities in Blount disease. Some of the proposed methods were closing wedge, opening wedge, dome, serrated, and inclined osteotomies [10].

Various fixation procedures were described, including cast immobilization, smooth pins and wires, interfragmentary screws, plates and screws, and external fixators. The most common procedures of genu varum repair were open and closed high tibial osteotomies. Various methods were used to maintain the open wedge of the medial tibia osteotomy in children, including iliac crest grafts, orthopedic plates, screws, and artificial bone replacements [9].

These treatments might cause extra pain, discomfort, an ugly scar, and infection if performed anywhere other than the surgery site. Moreover, bone replacements were expensive. A second procedure to remove the implant would be required if plates and screws were used [10].

Our study aimed to find a better, cheap, and comfortable method of maintaining the open wedge of valgus tibial osteotomy for genu varum deformity without adding cost, ugly scar, or a re-operation for the implant removal. Our primary objective was to determine the results, advantages, and disadvantages of using autologous fibular graft in open wedge high tibial osteotomy.

Regarding the demographic data of the studied patients, the age ranged from 3 to 12 years, with a mean of 4.69 years. Females represented 38.89% of patients while males represented 61.11%. We also analyzed the distribution of the studied patients according to the cause and laterality. Post rickets deformity occurred in 72.22%, while 55.55% of patients had a bilateral deformity. Among 28 limbs, 60.72% had been fixed by cast, 25% underwent cast and K wires, 7.14% had cast and staples, while 7.14% had plate fixation.

Nwachukwu had a female to male predominance in comparative research. Twelve girls and five males represented 71% and 29 % of children with genu varum abnormalities. Sixty-nine percent of the children were diagnosed for the first time, whereas 31% underwent surgery and were experiencing recurrence. The left leg (63%) was more damaged than the right (37%). Fibula osteotomy was performed at less than 10 cm below the fibula neck [5].

We studied the change in the angle of deformity among the studied patients pre and postoperatively during our work. There was a statistically significant change in the tibiofemoral angle (significantly decreased postoperatively) and medial proximal angle (significantly increased postoperatively).

The tibiofemoral angle was corrected from 26.89 ± 6.11 preoperative to 9.01 ± 1.28 postoperative, and the medial proximal tibial angle was corrected from 76.39 ± 3.15 degree preoperative to 94.78 ± 2.56 postoperative.

Overall, according to the mechanical axis correction and Schoenecker's criteria, good in 16 cases represented about 88.90%, fair in one case represented about 5.55%, and poor in one represented approximately 5.55%. There was a statistically non-significant relation between the findings and either age or gender of the studied patients.

According to Kaewpornsawan, 88% of the children under the age of four were effectively treated with a single osteotomy. In contrast, only 32% of children above the age of four had satisfactory outcomes following a single osteotomy. More significantly, the proportion of positive outcomes decreased [11].

Several authors utilized various techniques to keep the osteotomy in place, ranging from porous hydroxyapatite to internalfixators. Docquier and his colleagues employed allografts in the multiple osteotomies due to the fewer surgical sites, shorter operation times, less postoperative discomfort, and avoiding issues associated with autogenous graft harvesting. Nevertheless, he mentioned that autogenous grafts remained the gold standard. After three years of observation, their worries of fibular harvest problems included distal migration of the fibular head, talar tilt, proximal migration of the lateral malleolus, and non-materialized diaphyseal tibial valgus [12].

Regarding complications in our study, 88.9% had no complications, while 11.1% had postoperative complications in the form of superficial infection and residual deformity. We also found good results with cast and fibular grafts. There was a statistically non-significant relation between the outcome and the cause of the deformity.

Miller and colleagues reported a peroneal nerve palsy, a compartment syndrome, and neurovascular complications while analyzing the complications after medial opening wedge high tibial osteotomy [13].

In research done by Kaewpornsawan, it was shown that individuals who had surgery when they were five years old or older had a 76% recurrence risk, compared to a 31% recurrence in those who had surgery before that age [11].

On 18 tibiae, Hayek performed an oblique, incomplete, closing-wedge, proximal tibial osteotomy with lateral tension plate fixation. The advantage of this approach was that it did not need to reduce or eliminate motion in a cast, but owing to a fracture of the medial cortex, an overcorrection might occur, the limb might shorten, and the internal fixation would need to be removed [14].

According to Ogbenudia and colleagues, proximal fibular osteotomy caused more significant peroneal nerve injury than distal fibular osteotomy. These findings came from a study evaluating the degree of fibula osteotomy and the frequency of peroneal nerve palsy in proximal tibial osteotomies [15]. In our study, we didn't have any peroneal nerve palsy, compartment syndrome, or neurovascular complications.

Conclusion

Because of its strength, durability, cost-effectiveness, ease of graft harvest, and minimal incision and pain sites, it is concluded that the autologous fibular strut graft is an excellent graft for maintaining open wedge medial tibial osteotomy. We propose an autologous fibular graft as a viable alternative for maintaining opening wedge medial tibial osteotomy in genu varum correction. In addition, further research is required to examine the aspects of this issue.

Institutional Review Board Statement

The experimental procedures of the current study were approved by the Ethics Committee at the Faculty of Medicine, Zagazig University (Alsharquia, Egypt) (code #6431-22-9-2020); the work was performed following the Declaration of Helsinki.

Informed Consent Statement

Written informed consent was provided by all participants after a clear explanation of the study.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author.

Author Contributions

Conceptualization, E.S.; A.Z and E.S.S.; methodology, A.A.; E.S.; A.Z.; validation, A.Z and E.S.S; formal analysis, E.S.; A.Z and E.S.S.; the investigation, E.S.; A.Z and E.S.; resources, A.A.; and E.S.; data curation, E.S.; A.Z and E.S.S; writing—original draft preparation, A.A.; and E.S.; writing—review and editing. A.A.; and E.S.; supervision, E.S.; A.Z and E.S.S.; All authors have read and agreed to the published version of the manuscript

Conflict of interest

Authors declare no conflict of interest.

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