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Original Research Article

Comparative analysis of clinical and functional outcomes in late adolescents with genu valgum undergoing corrective osteotomy: a study of K-wire fixation versus plate osteosynthesis

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ABSTRACT

Background: Knee alignment typically transitions from varus to valgus during growth, stabilizing around 6° valgus by age 11, with interventions necessary for exaggerated valgus in adolescence. Surgical options for genu valgum correction involve osteotomy or guided growth procedures, with distal femur osteotomy being common in late adolescents and adults, though limited literature exists on outcomes with Kirschner wires (K-wires) and plate fixation. A prospective study is proposed to assess clinical, radiological, and functional outcomes in correcting genu valgum from the distal femur.
Methods: A prospective, randomized, single-center clinical trial with 50 patients with genu valgum deformity not responsive to conservative management. Patients underwent thorough pre-operative evaluation followed by medial closed wedge osteotomy with K-wire or plate fixation. Assessment at 24 weeks included Bostman et al knee scoring, visual analog scale (VAS), passive range of motion evaluation, Likert scale and findings were compared.
Results: Cohort of 50 patients, comprising 55% females and 45% males, with a mean age of 20.76 years, no significant differences were observed in age distribution or gender between the two treatment groups (K wire fixation and plate osteosynthesis). At 24 weeks, there were no significant differences between the groups in terms of Bostman knee score, VAS score, or range of motion, indicating similar outcomes with both treatment modalities.
Conclusions: Distal femoral medial closing wedge osteotomy with K-wire fixation offers a cost-effective and practical solution for genu valgum correction, particularly beneficial in resource-limited settings like India, providing comparable outcomes to plate fixation in late adolescents.

Keywords: Plate osteosynthesis, Distal femoral osteotomy, Late adolescents, K-wire fixation, Genu valgum

INTRODUCTION

Throughout the growth process, the coronal alignment of the knee undergoes various stages. It begins with a varus alignment at birth and transitions into a neutral axis alignment at approximately 18 months of age. By around 48 months, the knee exhibits maximal valgum, which gradually decreases to reach a physiologic adult amplitude of approximately 6° of valgus at around 11 years of age.[1] Numerous healthy children exhibit variations in the angles of the knee, and in the majority of cases, these variations improve naturally with growth, requiring no intervention.[1]

Nevertheless, a minority of individuals may not experience the expected correction, and in some instances, a child with an initially normal knee might develop an exaggerated valgus in adolescence.[2] Without correction, this valgus may persist into adulthood. There are two primary surgical approaches for addressing angular deformities in children: osteotomy with either acute or gradual correction, or the utilization of a temporary or permanent guided growth

procedure.[3] The necessity for surgical intervention is contingent on the extent of the deformity and the age of the patient. This is essential to avert the risk of late-onset degeneration and arthritis, while also aiming to enhance performance in sports and related activities.[3,4] In instances where the physis is still open, gradual growth modulation techniques such as stapling, percutaneous transphyseal screws prove effective in correcting deformities. It's crucial to note that these methods lead to permanent growth arrest. Therefore, precise calculations regarding the remaining growth and optimal timing for the surgical procedure are imperative. On the other hand, temporary epiphysiodesis, such as the use of eight-plate stapling, is a reversible approach. This allows for an earlier intervention, and upon removal of the implant, growth resumes.[4,5] In cases of significant valgus malalignment in a skeletally mature patient, corrective osteotomy can be performed, with or without internal or external fixation. The deformity may arise from the distal femur, proximal tibia, or knee joint, with the distal femur being the most common cause. Depending on the location of the deformity, correction of genu valgum can be achieved through either femoral supracondylar or high tibial osteotomy. Various types of corrective osteotomies for the distal femur have been discussed in the literature, including lateral opening wedge, medial closing wedge, dome osteotomy, 'V' osteotomy, each with their own merits.[6,7] There is a paucity of literature concerning the functional outcomes of medial close wedge osteotomy with Kirschner wires (K-wires) fixation and plate fixation as it's an effective and cheaper methods of getting the desired correction with a minimal soft tissue and bony injury. Since genu valgum is commonly seen due to high prevalence of vitamin D deficiency, we envisioned a prospective study to investigate the clinical, radiological, and functional outcomes following the correction of genu valgum deformity originating from the distal femur.

Objectives

This study aims to compare the clinical and functional outcomes of late adolescent patients undergoing extraphyseal medial close-wedge osteotomy for genu valgum using either K-wire fixation and plate fixation. The specific objectives are to evaluate post-operative complications, assess clinical outcomes in terms of mobility restoration and deformity correction, and determine functional outcomes related to patient rehabilitation and satisfaction. By analyzing these factors, the study seeks to identify the optimal fixation method that minimizes complications while maximizing clinical and functional recovery.

METHODS

Trial design

This study is a prospective, randomized, open, blinded, single-center clinical study. The trial was conducted according to the principles of the consolidated standards of reporting trials (CONSORT).

Site of the study

The study will be conducted from February 2024 to August 2024 at the Department of Orthopedics, Topiwala National Medical College and BYL Nair Charitable Hospital, Mumbai, Maharashtra, India.

Participants

After receiving the approval from the institutional ethics board committee for the study. A total of 50 patients from the outpatient department (OPD), Department of Orthopedics, TNMC and BYL Nair hospital who were clinically and radiologically diagnosed to have Genu valgum deformity not responding to conservative line of management and willing to participate were included in this study. A written informed consent regarding participation was obtained before recruitment. The complete procedure of the study was explained to all participants in their language by the investigator before recruitment. Rules for the inclusion and exclusion criteria will be followed in selecting the patients.

Inclusion criteria

Patient should have a bilateral genu valgum deformity with an intermalleolar distance (IMD) exceeding 10 cm, or a unilateral genu valgum deformity with a tibiofemoral angle greater than 15 degrees, mechanical axis deviation (MAD), and a mechanical lateral distal femoral angle (mLDFA) less than 84 degrees. Additionally, they should have a normal medial proximal tibial angle (MPTA), a fused distal femoral physis as shown on X-ray examination, and a deformity originating from the distal femur confirmed through clinical and radiological screening. Eligible patients should be between 16 and 25 years old.

Exclusion criteria

Exclusion criteria include any neurovascular deficit in the ipsilateral limb, the presence of any form of arthritis or ligamentous laxity, a history of significant trauma to the knee, unwillingness to participate in or undergo surgery, and any neurocognitive impairments such as cerebrovascular disease or mental retardation.

Pre-operative evaluation was done thoroughly including blood tests, *viz.* serum calcium/phosphate levels, serum alkaline phosphatase, and kidney function tests, were performed as part of the preoperative evaluation. Patients presenting with active underlying metabolic disorders, such as rickets and osteomalacia, underwent initial medical management before considering surgical intervention. Through clinical examination will be done and preoperative range of motion and ligament stability will be documented. All participants included in the study underwent radiographs of standing anteroposterior (AP) long limb films (X-ray scanogram). This imaging technique involved radiographing both lower limbs

together, capturing views from the hip, knee, and ankle joints. Additionally, standard weight-bearing X-ray views, including AP and lateral views, were obtained for the knees involved in the study. All the angles around the knee, CORA, will be documented.

All patients underwent surgery under suitable anesthesia (general/spinal/epidural), positioned supine on a radiolucent operating table designed for C-arm guidance. A pneumatic tourniquet was applied to the proximal thigh. To prevent pressure in the popliteal area, the involved knee was flexed to 60 degrees during the surgery, with the assistance of a large bolster placed underneath.

25 patients under went open reduction and medial closed wedge osteotomy with K-wire fixation through medial approach while the later underwent open reduction and medial close wedge osteotomy with plate fixation through lateral approach.

Group 1: K-wire fixation

A 5 cm incision is made over the adductor tubercle, with dissection through the avascular plane in the vastus medialis oblique fascia and the intermuscular septum. The intermuscular septum is incised along the femur using electrocautery, and soft tissues are dissected off the posterior femur using a blunt retractor. Radiolucent Hohmann retractors are positioned to protect neurovascular structures. Dissection extends distally for optimal exposure of the anteromedial femoral condyle. K-wires mark the osteotomy cut, guiding the resection of a wedge. After confirming the wedge size, additional K-wires are placed to establish the proximal margin. The osteotomy is performed with osteotomes or a saw, and the wedge is closed and fixed using two to three K-wires. Reduction is confirmed with an image intensifier, a drain is inserted, closure is done in layers, and an above-knee slab is applied. K-wires are cut, and pin track dressing is completed. All patients were advised regarding post-operative care. The possibility of pain increasing during the initial two weeks was explained to the patient. Antibiotic and adequate analgesia for given for pain relief. Patients were advised strict immobilization for 4 weeks and avoid strenuous activities by the extremity under study after the surgery wire removal was done 4 weeks post operatively and physiotherapy regime and protocol by certified physiotherapists at the institution was incorporated for patients in the form of range of motion exercises for the knee with passive mobilization techniques mobilizations was started 6 weeks post-operative period (Figure 1).

Group 2: plate fixation

A 8 cm incision is made over the lateral aspect of distal femur proximal to the joint line, with dissection through the avascular plane through the vastus lateralis. intermuscular septum is incised along the femur using electrocautery, and soft tissues are dissected off the posterior femur using a blunt retractor. Radiolucent Hohmann retractors are positioned to protect neurovascular structures. Dissection extends distally for optimal exposure of the anterolateral femoral condyle. K-wires mark the osteotomy cut, guiding the resection of a wedge. After confirming the wedge size, additional K-wires are placed to establish the proximal margin. The osteotomy is performed with osteotomes or a saw, and the wedge is closed by manual reduction and 8-hole distal femur locking plate is used for fixation of the bone. Closure is done in layers with drain in-situ. Patients were advised strict bib weight bearing immobilization for 6 weeks. Physiotherapy regime and protocol by certified physiotherapists at the institution was incorporated for patients in the form of range of motion exercises for the knee with Passive mobilization techniques mobilizations was started 2 weeks post-operative period (Figure 2).

Figure 1: Pre-operative scannogram of 19-year-old patient with bilateral genu valgum.

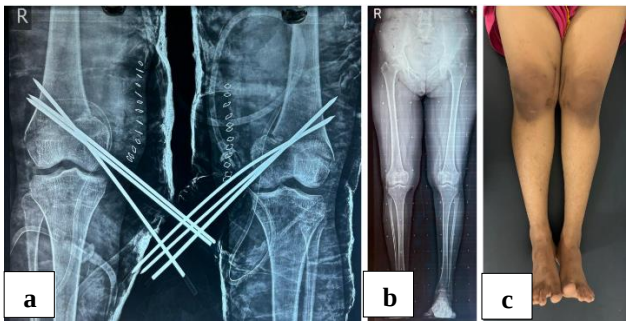

Figure 2: (a) Patient managed with medial closed wedge osteotomy and K-wire fixation with above knee casting, (b) showing follow up scannogram at 6 week post-operative, and (c) showing good clinical correction.

Assessment and follow-up

Upon enrollment in the study, demographic information, baseline clinical observations, pain duration, affected side dominancy, and any associated comorbidities were systematically recorded. Relevant X-ray and scanogram findings were also documented, and special investigations were conducted based on the identified comorbidities in each case. Follow-up assessments were scheduled at the 6th, 12th, and 24th weeks for all patients in both groups. Pain and functional evaluations, utilizing the visual analog scale (VAS) and the Bostman et al knee scoring to be performed at each follow-up.[8] Any adverse effects were diligently observed, documented, and reported. All collected data at 24 weeks were meticulously recorded in a designated case report form (CRF) tailored for the project and further organized in excel sheets for comprehensive analysis.

Figure 3 (a and b): 18-year-old patient with genu valgum (right > left).

Figure 4: (a) Right knee radiographs AP and lateral showing medial closed wedge osteotomy with plate fixation, and (b) scannogram showing good restoration of alignment and correction of deformity.

Outcome measures

The primary outcome measure in this study was Bostman et al knee scoring system and VAS at the 24-week follow-up. Passive range of motion (ROM) was assessed with a goniometer and Patient satisfaction regarding changes in pain and function was gauged using a five-point Likert scale ("worse," "unchanged," "unsatisfactory improved," "satisfactory improved," and "good to very good improved"). Bostman knee scores of 30 to 26 classified as excellent, 25 to 20 good and less than 20 unsatisfactory.

Statistical analysis

The data was inputted into Microsoft excel (Windows 7, version 2007), and analysis was conducted using the statistical package for social sciences (SPSS) software for Windows (version 22.0; SPSS Inc, Chicago). Descriptive statistics, including mean and standard deviation for continuous variables, and frequencies and percentages for categorical variables, were computed. The association between variables was examined using the Chi-square test for categorical variables, while the unpaired t-test was employed to compare the means of quantitative variables between cases and controls. Bar charts and pie charts were utilized for visual representation of the analyzed data. The significance level was set at 0.05.

RESULTS

Our 50-patient cohort included 26 females (55%) and 24 males (45%). The mean age of the patients in our cohort was 20.76 (1.92) years. We had 15 cases of left-side deformity, 13 cases of right-sided deformity, and 22 cases with bilateral deformity. Patients were categorized in two groups of 25 each of operated cases of genu valgum if group A – operated with K wire fixation and group B – plate osteosynthesis and results are as followed by independent t test, Chi square test.

Distribution of age (years) was comparable between group A and B. (16-18 years 4% both respectively, 19 to 21 years - 52% versus 60% respectively, 22 to 25 years 32% versus

24% respectively). Mean±SD of age (years) in group A was 20.76 and 20.48 for group A and B, with no significant difference between them (p value: 0.807) (Table 1).

Table 1: Comparison of age between study groups (n=50).

Age (in years)	Group	
	K-wire fixation (n=25), N (%)	Plate osteosynthesis (n=25), N (%)
16-18	4 (16.0)	4 (16.0)
19-21	13 (52.0)	15 (60.0)
22-25	8 (32.0)	6 (24.0)
Mean (SD)	20.76 (1.92)	20.48 (1.87)

Chi-square test, p value=0.807, not significant

Comparison of gender between group A and B was done by Chi square test. Distribution of gender was comparable between group A and B (female 48% versus 56% respectively, male 52% versus 44% respectively) (p=0.0571) (Table 2).

Table 2: Comparison of gender between study groups (n=50).

Gender	Group	
	K-wire fixation (n=25), N (%)	Plate osteosynthesis (n=25), N (%)
Female	12 (48.0)	14 (56.0)
Male	13 (52.0)	11 (44.0)

Chi-square test, p value=0.571, not significant

Comparison of Bostman knee score at 24 weeks between group A and B was done by unpaired t test, proportion of patients with Bostman knee score >85 percent was similar in both the groups A and B and was comparable.

Mean±SD of Bostman knee scoring in group A was 27.08 which was comparable to group B 26.96 (Table 3) with no significant difference (p=0.801).

Table 3: Comparison of Bostman knee score at 24 weeks between study groups (n=50).

Parameter	Group	
	K-wire fixation (n=25), N (%)	Plate osteosynthesis (n=25), N (%)
Bostman score	27.08 (1.47)	26.96 (1.85)

Unpaired t test, p value=0.801, not significant

Comparison of VAS scores between group A and B was done by unpaired t test, VAS scores was similar in both the groups A and B and were comparable.

Mean±SD of VAS scores in group A was 2.76 (1.20) which was comparable to group B 2.72 (1.24) (p value=0.908) (Table 3) with no significant difference (Table 4).

Table 4: Comparison of VAS score at 24 hours between study groups (n=50).

Parameter	Group	
	K-wire fixation (n=25), N (%)	Plate osteosynthesis (n=25), N (%)
VAS	2.76 (1.20)	2.72 (1.24)

Unpaired t test, p value=0.908, not significant

Comparison of range of motion between group A and B was done by unpaired t test, range of motion was similar in both the groups A and B and were comparable.

Mean±SD of range of motion at the knee in group A was 107.60 (9.25) which was comparable to group B 106.40 (9.52) (p=0.653) (Table 5) with no significant difference.

Table 5: Comparison of range of motion between study groups (n=50).

Parameter	Group	
	K-wire fixation (n=25), N (%)	Plate osteosynthesis (n=25), N (%)
Flexion	107.60 (9.25)	106.40 (9.52)

Unpaired t test, p value=0.653, not significant

DISCUSSION

Genu valgum in adolescents and young adults often leads to orthopedic consultations. This malalignment in the coronal plane heightens the likelihood of developing and worsening osteoarthritis.[9,10] The altered biomechanical stress on the knee caused by the mechanical axis shifting laterally in genu valgum can result in anterior knee pain, patellofemoral instability, a circumduction gait, and challenges with running. For significant valgus deformities, surgical correction is necessary to enhance biomechanics, thereby improving appearance, gait, and function.[11] A varus-producing distal femoral osteotomy (DFO) effectively alleviates pain and improves function in patients with isolated lateral compartment disease and valgus alignment. It can be combined with other joint-preserving techniques like cartilage restoration and meniscal transplantation. With advancements in knee arthroplasty, DFO is primarily used in younger patients to preserve the native knee joint and delay or avoid total knee arthroplasty.[12]

Medial closing wedge distal femoral osteotomy (CWDFO) and lateral opening wedge distal femoral osteotomy (OWDFO) are two primary surgical options for treating lateral compartment arthritis with valgus knee deformity.[13] Clinical outcomes, including survival rates and patient-reported outcomes, are comparable between medial CWDFO and lateral OWDFO.[12] Medial CWDFO offers advantages such as faster healing time and a lower risk of hinge fracture due to direct bony opposition along the cortex. However, it is technically more demanding and relies heavily on precise preoperative planning for accurate bony resection.[14,15] Generally, postoperative

rehabilitation is quicker, and weight bearing can begin 2 to 4 weeks earlier compared to lateral opening wedge osteotomy.[16]

The wedgeless "V" shape distal femoral osteotomy involves a smaller surgical exposure and shorter operating time. When performed under a tourniquet, it results in minimal bleeding and provides inherent stability at the osteotomy site due to the apex penetrating the distal metaphysis. This technique reduces the incidence of knee stiffness as it does not involve the knee joint. Other benefits include no limb length discrepancy, faster union at the osteotomy site, and non-rigid fixation, allowing for postoperative adjustments.[17,18]

Aglietti et al first described the supracondylar "V" osteotomy in a study involving 14 patients aged 15 to 77 years. The procedure improved the mean tibiofemoral angle from 21° preoperatively to 2.3° postoperatively. Most patients (9) had genu valgum due to lateral compartment osteoarthritis (ages 52 to 77), while the remaining 5 had genu valgum from other causes. The authors reported satisfactory results, noting the procedure's simplicity, low morbidity, good stability, lack of need for internal fixation, and the ability to adjust alignment with a postoperative cast.[17]

Gupta et al evaluated the efficacy of "V" osteotomy with a customized "L" buttress plate, with 95.7% of patients achieving excellent outcomes according to Bostman's score. Significant improvements were noted in intermalleolar distance (IMD), clinical and radiological tibiofemoral angles (TFA), and lateral distal femoral angle (LDFA), mirroring our findings in both clinical and radiological outcomes.[18]

In their study, Arora et al showcased substantial enhancement in radiographic angles and mechanical axis deviation, alongside outstanding functional outcomes observed in 44 of the 46 cases. This inherently stable approach incorporates a reduced posterior arm of the V-shaped osteotomy, permitting the proximal cortical bone to penetrate the broader distal metaphysis for correcting deformity. Subsequently, plate osteosynthesis ensures the safety and efficacy of the procedure, yielding favorable clinical results.[19]

A study by Rustag et al evaluated the outcomes of a simple, cost-effective supracondylar wedge-less metaphyseal distal femoral osteotomy and plaster of Paris cast immobilization for genu valgum correction in older children and adolescents. Results from 46 limbs in 29 patients showed significant improvement in tibiofemoral and intermalleolar distances with excellent knee scores post-intervention. The procedure, ideal for low-income settings, had minimal complications, with all patients regaining full knee motion after physical therapy proving the need for minimal fixation following distal femoral osteotomies.[20]

Sidhu et al their study on adolescent patients with valgus knee deformities evaluated the effectiveness of wedge less distal femoral V osteotomy stabilized with K-wires. Preoperative TFA averaged 20.23±3.63 degrees, decreasing significantly to 5.5±0.73 at six months post-surgery, alongside reduced IMD and MAD. Bostman scores improved from 26.2±1.79 at three months to 29.47±0.9 at six months. Complications included infection, hypertrophic scar, and common peroneal neuropraxia, affirming wedge less distal femoral osteotomy as a viable option for genu valgus correction with advantages like minimal blood loss and early union.[21]

Verma conducted a study on correcting genu-valgum deformity in children and adolescents using distal femoral medial closing wedge osteotomy stabilized by a single K-wire. Among 27 limbs, 24 cases achieved excellent outcomes, while two had good functional results and one had unsatisfactory knee score. The study concludes that this technique is a viable option for genu valgum correction in this population.[22]

Our study embarks upon a thorough investigation into the efficacy of extraphyseal medial close-wedge osteotomy for rectifying genu valgum with plate osteosynthesis and K wire fixation in late adolescents. K-wire fixation involves the temporary insertion of wires to stabilize bone fragments, whereas plate osteosynthesis utilizes metal plates and screws to secure the osteotomy site. This inquiry is set against a backdrop of existing literature that underscores the critical importance of surgical intervention in this demographic.

Our study involved the late adolescent age group and utilized minimal implants, employing a 2-4 K-wires. We achieved excellent outcomes in demonstrating good functional results, radiological union and rehabilitation which was comparable to the post-operative outcomes from plate fixation. Noteworthy advantages of this technique include swift execution (operating time <45 min), potential for simultaneous correction in bilateral limbs, early union at the osteotomy site, minor alignment adjustments due to non-rigid K-wire fixation, limited immobilization duration in an above-knee cast (6 weeks), and avoidance of a second surgery for implant removal.

However, from our study and literature review, it is evident that closed wedge osteotomy with K wire fixation, when performed with proper indications and thorough preoperative planning, can yield satisfactory and successful results in operative correction of genu valgum deformity and is with comparable results to the traditional use of locking plate. Patients subjected to both the methods tend to experience good recovery periods, and optimum functional performance, including an expanded range of motion and an earlier return to weight-bearing activities. Furthermore, plate fixation facilitates early mobilization, a pivotal factor in the rehabilitation process, thereby expediting the resumption of daily activities and sports participation. However, the authors judiciously

acknowledge the imperative of further research endeavors characterized by larger sample sizes and extended follow-up periods to corroborate these findings and establish definitive treatment paradigms.

CONCLUSION

In conclusion, distal femoral medial closing wedge osteotomy with K-wire fixation emerges as a straightforward, cost-effective, and practical approach for correcting genu valgum deformity. Its ability to address deformities simultaneously in both limbs, along with its utilization of minimal and economical implants, underscores its suitability for healthcare settings in developing nations like India. We endorse this technique for late adolescents with closed physis, as it preserves bone stock while offering comparable clinical and functional outcomes to plate fixation, making it a cost-effective alternative.

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