Original Article

Modified Supracondylar Chevron Osteotomy for Correction of Genu Valgum Deformity in Constrained Resources

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Abstract

Background: Various types of corrective osteotomies of the distal femur have been described in the literature for genu valgum deformity such as lateral opening wedge, medial closing wedge, dome osteotomy, wedgeless spike osteotomy, and wedgeless "V" osteotomy. **Objectives:** We aimed this study to evaluate the effectiveness of our modified supracondylar chevron osteotomy in correction of deformity. **Materials and Methods:** It was a prospective intervention study. Thirty young adults between the ages of 13–30 years were enrolled in the study. Modified chevron osteotomy was done and fixed with medial locking plate. Patients were evaluated at 1 year of follow-up. **Results:** A total of 30 patients included in the study underwent surgical correction of genu valgum deformity. The average blood loss during surgery was 187 ml (range, 150–260 ml). The mean duration of hospital stay was 4.5 days (range, 3–7 days). The mean time to union of osteotomy was 14.9 weeks (range, 12–17 weeks). The mean preoperative clinical tibiofemoral angle (TFA) was 23.4° (range, 18°–28°) that improved after surgery to a mean postoperative value of 5.8° (range, 4°–7°) which was statistically significant ($P < 0.001$). The mean preoperative radiological TFA was 23.5° (range, 19°–28°) that improved to a mean postoperative value of 5.7° (range, 4°–7°) and that was statistically significant ($P < 0.001$). **Conclusion:** Supracondylar chevron osteotomy and internal fixation with anatomically designed medial distal femur locking plate with the modified technique of using multiple 30-cm long solid 4.3-mm drill bits and using increasing width osteotome has the advantage of avoiding C-arm use and avoiding nibbling of the medial cortex. Keeping both limbs in the surgical field and replicating the clinical TFA with the help of sterile metal goniometer is a simple, safe, cost-effective procedure with a short learning curve that can be used for correction of genu valgum deformity in adolescent and young adult patients in constrained resource setup.

Keywords: Chevron, genu valgum, supracondylar osteotomy

Introduction

Coronal plane deformities around knee joint are one of the common disorders presenting to orthopedic clinic. Genu valgum is a frequently encountered coronal plane deformity. The normal alignment in adults is 5°–7° of valgus which is achieved by the age of 6 years. Nutritional rickets is one of the leading causes of these deformities in developing countries.[1] The patient may present asymptomatically with cosmesis as the only concern or with chief complaints of frequent falls due to knock knees, anterior knee pain due to malalignment, or patellofemoral problems due to increased Q angle. The origin of the deformity may be from the distal femur, proximal tibia, or knee joint depending on the pathophysiology.[2-4] However, the usual origin of genu valgum is from the distal femur that is confirmed by "flexion test" and various angle measurements on standing radiographs of both lower limbs including hips, knees, and ankles.[3,4] Various types of corrective osteotomies of the distal femur have been described in the literature such as lateral opening wedge, medial closing wedge, dome osteotomy, wedgeless spike osteotomy, and wedgeless "V" osteotomy.[5-15] Still, there is no consensus regarding the most accepted osteotomy for coronal plane deformity around the knee. The distal femoral wedgeless "V" osteotomy was originally described by Aglietti *et al*., however, the primary indication of performing the surgery was genu valgum secondary to lateral

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compartment osteoarthritis.[5] Correction of genu valgum deformity is basically aimed at the correction of the mechanical axis of the lower limb.

The distal femoral chevron-shaped osteotomy on approached through the medial side is a safe, effective, and easy to perform surgery with a short learning curve. Various studies have been done on supracondylar V osteotomy. In this study of correction of "distal femur origin-genu valgum deformity" done in constrained setup, i.e., without C-arm IITV, we have made a modification to the usual technique that to make osteotomy parallel to the joint line, we have used multiple 30-cm long solid 4.3-mm drill bits, and in place of nibbling the anterior and posterior medial cortex (as described originally), we have used a progressively increasing width osteotome that automatically leads to more space on the medial side for penetration of perfectly "sharp-shaped" medial proximal cortex into the wider distal cancellous condyle for correction of deformity. Keeping both limbs in the surgical field and replicating the clinical tibiofemoral angle (TFA) with the help of intraoperative sterile, metal goniometer was also a modification. The aim of the corrective surgery was to correct the deformity (thereby addressing the patellofemoral issues) without C-arm IITV use, avoiding joint penetration, avoiding limb length discrepancy, and achieving economically viable fixation for early range of motion. In this study, we have evaluated the results of supracondylar chevron osteotomy by this new modified technique on 30 patients presenting with genu valgum deformity with a follow-up period of 1 year.

The primary aim of the study was to evaluate the effectiveness of our modified osteotomy to correct the deformity. The secondary aim was to evaluate blood loss, surgical time, functional and radiological outcome at 1-year follow-up.

Materials and Methods

Study design and patients

This study was a prospective clinical study with 30 adolescent or young adults aged between 13 and 30 years presenting with a genu valgum deformity from a period of April 2017 to April 2019, with 1 year of follow-up for each patient. The patients having genu valgum deformity who were selected after qualifying inclusion criteria were clinically assessed and underwent radiological and biochemical investigations. Patients having a TFA of more than 15°, intermalleolar distance (IMD) of more than 10 cm, origin of the deformity in the distal femur, and no active metabolic abnormality were considered for inclusion in the study. Patients who had severe collateral ligament instability, unstable knee with evidence of subluxation, and sagittal plane deformity (fixed flexion deformity >15° or genu recurvatum) or having active metabolic disease were excluded from the study. The biochemical investigations included serum calcium/phosphate, serum alkaline phosphatase, and kidney function tests. Patients having underlying active metabolic disorder were first treated before inclusion in the study. Both clinical and radiological assessment was done preoperatively.

The origin of the deformity was clinically assessed by the knee flexion test. Measurement of the IMD was done while in standing position with the knee extended and the medial surface of both the knees touching each other and patella facing forward. Measurement of the clinical TFA was done by the angle subtended between the line drawn from the ipsilateral anterior superior iliac spine (ASIS) to the center of the patella and from the center of the patella to the center of the ankle joint. Functional assessment was done using Bostman knee score. The standing anteroposterior (AP) radiograph was taken including both hips, both knees with patella facing forward, and both ankles to measure the angles to quantify the deformity. Measurement of the radiological TFA was done as the angle formed between the anatomical axis of the femur and tibia. The lateral distal-femoral angle (LDFA) was measured as the lateral angle between the mechanical axis of the femur and the articular surface of the distal femur. Evaluation was done on the basis of pre- and postoperative clinical (IMD and TFA) and radiological (TFA and LDFA) parameters.

Operative procedure

The operation is performed under anesthesia (general/spinal) with the patient supine on operating table without a tourniquet and with both limbs (without tourniquet) from ASIS to the midfoot under vision and in surgical field, which helps in checking intraoperative limb alignment. The surgery was performed with knee flexed to avoid risking vital structures in the popliteal area.

A medial longitudinal skin incision of approximately 8–10 cm long was made extending from the level of the medial joint line to 5 cm above the adductor tubercle [Figure 1]. The deep fascia was incised in line with the incision. The vastus medialis was identified and elevated anteriorly. The epiphyseal vessels traversing transversely were identified just proximal to the adductor tubercle [Figure 2]. The periosteum was incised and elevated anteriorly and posteriorly to expose the femoral metaphysis and to protect the popliteal vessels. The adductor tubercle was identified.

Figure 1: Incision on the medial side

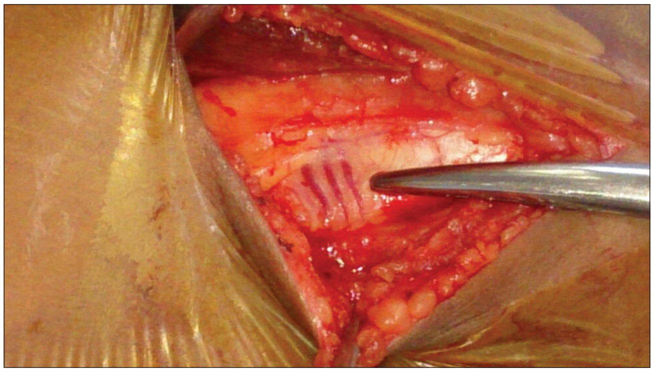

Figure 2: Intraoperative photograph showing epiphyseal vessels crossing transversely in the distal femur

The apex of the osteotomy site was identified one fingerbreadth proximal to the adductor tubercle. The osteotomy is "V" shaped in the frontal plane, with both arms meeting at 90°. The anterior arm of the "V" is slightly longer than the posterior arm [Figure 3]. The slightly longer anterior arm resists backward rotator forces imposed by the pull of the gastrocnemius as the posterior cortex is much stronger than the anterior cortex. First, a 30-cm long 4.3-mm solid drill bit was inserted intra-articularly skimming the femoral condyles so that all the osteotomy planes were parallel to this long and thick solid drill bit. The osteotomy line was marked using cautery. Then, multiple 30-cm long and 4.3-mm thick solid drill bits were drilled along the marked line of osteotomy. The reason to use long drill bit was to ensure easy parallelism, and the reason to use thick drill bit was to avoid skewing of the bits. All the drill bits were placed parallel to the intra-articular drill bit or in other words parallel to the joint line in AP view and straight in lateral view with no anterior or posterior angulation. The drill bits should only engage in the lateral cortex and should not cross the lateral cortex. The osteotomy was then done with an osteotome that has an increasing width as we go toward the handle of the osteotome [Figure 4]. This leads to creation of an osteotomy that is "sharp" and has less width laterally and more width medially. This modified technique of doing supracondylar chevron osteotomy leads to creation of more space medially and a beak laterally. Correction is then achieved by extension of knee and application of gentle manual varus force which leads to perfect penetration of sharp proximal medial cortex into the wider distal cancellous femoral condyle. Using an osteotome decreases the risk of heat necrosis and helps in thinning the lateral cortex without undue periosteal disruption. An aggressive division of the periosteum and soft tissues on the lateral side can make the osteotomy unstable. The correction is obtained primarily by the medial penetration and impaction of the distal cancellous bone. No wedges were taken during the procedure. The intraoperative alignment of the leg was repeatedly checked in extension by measuring clinical TFA with the help of a sterile metal goniometer to obtain the final alignment equal to the other limb. In cases of bilateral involvement, sequential same siting surgery can be done using the same methodology. The osteotomy was then stabilized further by internal fixation with an anatomically designed medial distal femur locking plate [Figure 5]. Stability of the osteotomy in flexion and extension was checked on the table after correction of the deformity.

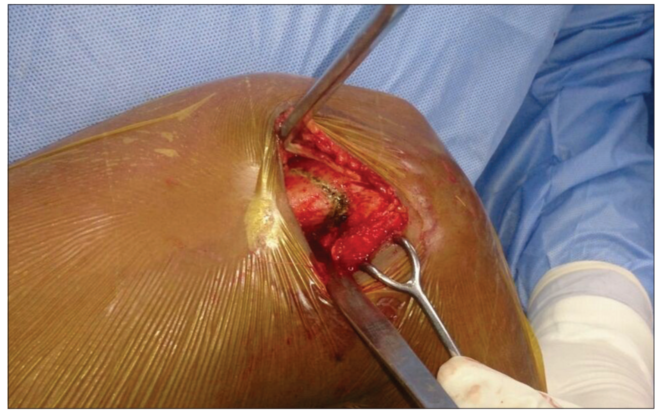

Figure 3: Intraoperative photograph showing planned osteotomy proximal to epiphyseal vessels with anterior limb longer than the posterior

Postoperative care

Patients were kept nonweight-bearing for 3 weeks and followed by partial weight-bearing with walker as tolerated. The passive range of motion was started at 1 week. The active assisted range of motion exercises was started at 2 weeks. Patients were then reviewed at 4 weekly intervals for the first 3 months (till radiological union of osteotomy site) and then at 3 monthly intervals. Standing radiographs' both AP and lateral views were taken at 3 months. The patients were evaluated clinically and radiologically for the alignment and status of the union of the osteotomy. The range of motion was assessed at every visit. Gradual full weight-bearing was allowed after clinicoradiological union of osteotomy site. The IMD, clinical and radiological TFA, and LDFA were calculated at the final follow-up, i.e., at 12 months. Functional assessment was done by Bostman score with score between 28 and 30 classified as excellent outcome, score between 20 and 27 as good, and a score below 20 as unsatisfactory. Radiological and clinical pictures of a representative case are shown in Figures 6-9.

Statistical analysis

All quantitative data were expressed as mean ± standard deviation. Statistical significance of differences in the mean values of continuous variables was determined using Student's *t*-test. Chi-square test was used for categorical variables. Fisher's exact test replaced Chi-square test when one of the cells in categorical variables was zero. SPSS version 14 (SPSS, IBM Company, Chicago, IL 60606, USA) was used for statistical analyses. $P < 0.05$ was considered to indicate statistical significance.

Ethical consideration

The study was conducted in accordance with the ethical principles that have their origin in the Declaration of Helsinki. It was carried out with patients' verbal and analytical approval before sample was taken. The study protocol and the subject information and consent form were reviewed and approved by a local ethics committee.

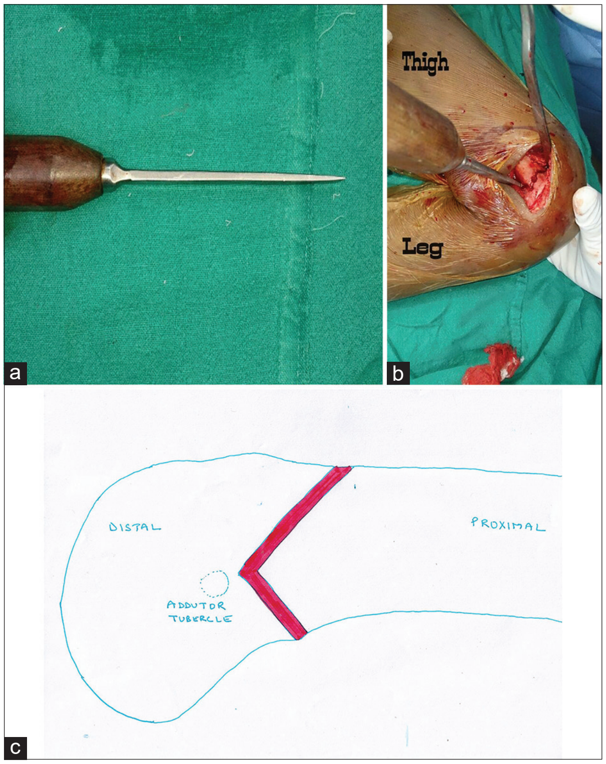

Figure 4: (a) Increasing width osteotome. (b) Osteotomy planes. (c) Schematic diagram depicting V-shaped supracondylar osteotomy from the medial side

Results

A total of 30 patients included in the study underwent surgical correction of genu valgum deformity with the modified technique of supracondylar chevron osteotomy and were followed up for 1 year. The mean age of the patients was 17.4 years (range, 13–23 years). There were 14 males and 16 females. Out of 30 patients, 23 patients presented with cosmetic deformity as the chief complaint, 10 patients had pain, 4 patients had gait abnormalities, and 3 patients had a history of fall while walking. The average blood loss during surgery was 187 ml (range, 150–260 ml). The mean duration of hospital stay was 4.5 days (range, 3–7 days). The mean time to union of osteotomy was 14.9 weeks (range, 12–17 weeks).

The mean preoperative IMD was 13.5 cm (range, 13–21 cm) that improved to a mean postoperative value of 2.3 cm (range, 1–5 cm) and that was statistically significant ($P < 0.001$). The mean preoperative clinical TFA was 23.4° (range, 18°–28°) that improved after surgery to a mean postoperative value of 5.8° (range, 4°–7°) which was statistically significant ($P < 0.001$). The mean preoperative radiological TFA was 23.5° (range, 19°–28°) that improved to a mean postoperative value of 5.7° (range, 4°–7°) and that was statistically significant ($P < 0.001$). The mean preoperative LDFA was 77.3° (range, 72°–81°) that improved significantly after corrective osteotomy to a mean postoperative value of 88.1° (range, 87°–91°) with $P < 0.001$. The mean preoperative Bostman knee score was 23.2 that improved significantly to a mean postoperative value of 28.1 ($P < 0.001$) and that falls in the excellent outcome category. All the patients had a complete preoperative knee range of motion after corrective surgery. There were no complications such as knee stiffness, recurrence of deformity, limb length discrepancy, reversal of deformity, or nonunion of the osteotomy site.

Figure 5: Anatomically designed medial distal femur locking plate

Discussion

Coronal plane deformities such as genu valgum are a frequent cause of outpatient clinic visit in the orthopedic department, especially among adolescent females and young adults. Malalignment in coronal plane increases the risk of development and progression of osteoarthritis.[16] The altered biomechanics and lateral shifting of mechanical axis in genu valgum deformity may lead to anterior knee pain, patellofemoral instability, abnormal gait, and difficulty in running. Severe genu valgum deformity needs surgical intervention to restore biomechanics and improve cosmesis, gait, and function. A large number of corrective distal femoral osteotomies have been described for genu valgum deformity because the most common site of deformity is distal femur.[17] Each of the corrective osteotomy procedure has its own advantages and disadvantages. A supracondylar linear distal femoral osteotomy is one procedure involving the crushing of the medial cortex and also requiring prolonged immobilization in a spica cast with a risk of subsequent knee stiffness.[5]

Dome osteotomy has its limitations that it requires special instruments, periosteal stripping, leads to postoperative instability, and the translation is required at the osteotomy site.[18] Supracondylar closing wedge osteotomy and internal fixation of osteotomy site by a rigid device such as anatomically designed locking plate is the most commonly practiced technique. Aglietti *et al*. performed supracondylar "V" osteotomy for the correction of valgus deformity secondary to lateral compartment osteoarthritis of the knee in the age

Figure 6: Preoperative radiograph of a patient having genu valgum deformity

Figure 8: Postoperative alignment of the clinically corrected genu valgum deformity on the right side

Figure 7: Postoperative radiograph of a patient 1 year after modified technique of supracondylar chevron osteotomy and internal fixation with anatomically designed medial distal femur locking plate

Figure 9: A patient is able to sit cross legged 3 months after the procedure

group 52–77 years and observed a correction from preoperative mean TFA of 21° to postoperative mean TFA of 2.3°.[5] They described this simple procedure with low morbidity, with good stability, without any internal fixation, and with the ability to adjust the alignment postoperatively with a cast. Further, its application has been extended to correction of genu valgum deformity in adolescent to young adults by few clinicians with uniformly satisfactory result.[17,19]

Gupta *et al*. performed "V" osteotomy at the level of the adductor tubercle and fixed the osteotomy with a customized "L" buttress plate and assessed the clinical and radiological outcomes. The parameters assessed were IMD, clinical TFA and Bostman score, and radiological TFA and LDFA. They observed an improvement from 13.8 to 1.5 cm in IMD, 23.5°–6.1° in clinical TFA, 22.2°–5.1° in radiological TFA, and 79.2°–89.1° in LDFA.[17] Nearly 95.7% had an excellent outcome on the basis of Bostman score. The clinical and radiological outcomes were similar in our study. Many studies have been done on distal femoral osteotomy and fixation with internal or external devices.

In this study, we performed a supracondylar chevron-shaped distal femoral osteotomy with modification in all the patients with genu valgum deformity included in the study. The procedure led to correction of the coronal plane deformity, thereby addressing the patellofemoral issues with no limb length discrepancy since this is a wedgeless osteotomy and no joint stiffness postoperatively. The modification which we made (as described in detail earlier) made it a good option in constrained resource setup. Internal fixation with an anatomically designed medial distal femur locking plate provides the advantage in the form of early mobility and rehabilitation.

Conclusion

Supracondylar chevron-shaped osteotomy and internal fixation with anatomically designed medial distal femur locking plate with the modified technique of using increasing width osteotome, longest thick drill bits, keeping both limbs under view, avoiding tourniquet, and use of intraoperative metal goniometer has given a distinct advantage while doing this surgery without C-arm IITV. It is a simple, safe, cost-effective procedure with a short learning curve that can be used for correction of genu valgum deformity.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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