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The use of dome shaped osteotomy and plating in correction of genu varum

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Abstract
Background: Leg genu varum abnormalities may be unilateral, bilateral, or part of a windswept deformity; they are often accompanied by internal tibial torsion. Physiological bowlegs, rickets, infections, traumatic growth plate injuries, neoplasms, skeletal dysplasia's, and Blount disease are among the many potential causes of genu varum deformities. Blount disease and rickets are common causes of genu varum deformities in Africa. Nevertheless, the precise prevalence of these disorders remains mostly unknown. Infantile Blount disease affects 37-62% of Caribbean babies, and one study puts the prevalence at 1/1200 live births. The incidence of rickets in various African countries ranges from 3% to 42%, highlighting the persistent nature of this health concern in emerging nations. Only 0.6% of children in a Gambia population survey had radiographic evidence of rickets, while 3.3% met clinical criteria for the disease. The most prevalent abnormality in this research was knock knee deformity (47%), followed by bilateral bow leg deformity (53%). The purpose of this review is to compare and contrast the functional, clinical, and radiological results of dome osteotomy with genu varum fixation using a T or L plate. In summary: The program takes into account the tibia's and femur's metaphyseal deformities when designing an automatic knee osteotomy. It then recommends the surgery with the right amount of opening to achieve the ideal mechanical axis without causing the joint lines to be too oblique. If the osteotomy of the proximal tibia is done within a certain range of deformity values, utilizing a defined procedure connected to a patented implant, it will provide favorable outcomes. A radically new method is necessary for the treatment of clearly visible Varus malformations. Corrective proximal tibial osteotomies for genu varum need thorough deformity analysis for surgeons to pick the right patients. Because of this, we may take the deformity's size and other features into account, which will lessen the likelihood of technical issues that might develop from correcting the patient utilizing the suggested method in conjunction with a custom implant.

Keywords: Topics covered, genu varum, plates, and dome shaped osteotomy

1. Introduction
Angular childhood is a prevalent time for lower limb abnormalities. This is usually only a deviation in the typical pattern of development and has no health consequences. A benign illness with a great prognosis is indicated by the presence of symmetrical deformities in the absence of symptoms, joint stiffness, systemic problems, or syndromes. Severe underlying causes may need therapy for asymmetrical deformities that are accompanied by discomfort, stiffness of the joints, or systemic diseases or syndromes [5].

Genu varum is a malformation of the knee joint where the centers of the knees are moved outside of the mechanical axis of the limbs, causing a change in the normal alignment of the limbs. According to van [43], this malformation makes the patient's legs seem like they're in a parenthetical position while they stand.

When osteoarthritis (OA) and medial compartment overload cause Varus malalignment and discomfort in the knee, a common surgical technique is high tibial osteotomy (HTO), also called proximal tibial osteotomy. In 1961, Jackson *et al*. first described HTO; in 1962, Wardle reported that Sir Robert Jones had discussed tibial osteotomies as a means of correcting genu varum caused by rickets [28].

But in 1985, the method became widely used in Coventry. In order to postpone or prevent knee replacement due to OA, HTO primarily aims to alleviate pain by releasing pressure on the medial joint compartment and repositioning the lower limb's mechanical axis, which slows down deterioration. After adjusting for varus knees, HTO reduces knee discomfort by transferring weight-bearing stresses to the side compartment, which is less impacted. Various wedge osteotomies may be performed, including open-medial, closed- lateral, progressive callus, and dome osteotomies [21].

While there are a variety of options for correcting genu varum, the effectiveness of the procedure and the choice of treatment strategy depend on thorough preoperative evaluations [39].

The purpose of this study was to assess the radiological, functional, and clinical results of dome osteotomy with T or L plate fixation in genu varum.

The knee joint's anatomy

The intricacy of the knee joint captivates everybody. The patella glides across the femur, and the tibia and femur articulate with each other [42].

Here we can see the articulation: the rounded femoral condyles are up above, the tibial condyles and their cartilaginous menisci are down below, and up front we can see the joint where the femur meets the patella. Hyaline cartilage covers the surfaces of the joints. It should be noted that the medial and lateral tibial plateaus are common clinical terms for the articular surfaces of the medial and lateral tibial condyles, respectively [3].

Type

The femur-tibial joint is a hinge-type synovial joint, but it may rotate to a certain extent. According to [10], the synovial joint that connects the patella to the femur is known as the plane gliding joint.

Anterior and posterior to the joint sits the capsule, which is a protective covering that is fastened to the articular surfaces. The suprapatellar bursa forms when the synovial membrane pouches upward under the quadriceps tendon due to the absence of the capsule on the front side of the joint. The vastus lateralis and medialis tendons provide lateral and medial support, respectively, to the patella capsule. A semimembranosus muscle termed the oblique popliteal ligament expands behind the joint and strengthens the capsule. [41] found that the popliteus tendon may exit via a capsule aperture located behind the lateral tibial condyle.

The big medial bone of the leg that bears the body's weight is called the tibia. In the knee, it connects to the femur's condyles. A little circular articular facet for the fibula head is located on the lateral side of the lateral condyle. At the back of the medial condyle is where the semimembranosus muscle enters. The pes anserinus bursa is located between the tendons of Sartorius, Gracilis, and Semitendinosus, which enter into the proximal shaft at the medial side. There is a tuberosity where the ligamentum patellae attach, at the point where the front edge meets the top of the tibia. Joint extension relies heavily on this tibial tuberosity and the ligamentum patellae [36].

The proximal tibia's anatomy

One of the leg's two bones is the tibia. Compared to its smaller and weaker sibling, the fibula, it is much bigger and stronger since it bears the body's weight. In the knee, the tibia joins the femur proximally, while in the ankle, it joins the fibula and talus distally. According to [1], the interosseous membrane connects the tibia to the fibula, which runs medial to it from the knee joint to the ankle joint.

Several significant landmarks serve as attachment sites for muscles and articular surfaces on the proximal end of the tibia. These include the medial and lateral tibial condyles, which are separated by anterior and posterior intercondylar areas. The menisci, anterior collateral ligament, and posterior collateral ligament all attach to these intercondylar areas. Because of its somewhat concave and round form, the medial condyle's superior surface fits snugly into a joint with the femur's medial condyle. Attached to all except the lateral border, the medial meniscus forms a sandwich between the tibia and femur at this joint. The lateral edge, on the other hand, reaches the medial intercondylar tubercle [1].

The lateral condyle's upper surface, in contrast, is almost an exact replica of the medial condyles. The lateral condyle of the femur is articulated with its spherical and slightly convex form. With the exception of the medial border, the lateral meniscus joins to every other edge. All the way to the lateral intercondylar tubercle the medial border reaches. The menisci are fibrocartilage pads that are put into the condyles to alleviate pressure that is conveyed from the femur (Lee).

A flattened surface known as the tibial plateau is formed by the combined superior surfaces of the condyles. The knee is a joint where the tibial and femoral condyles meet. The medial and lateral intercondylar tubercles are little protrusions that divide the joint surfaces. Both the front and posterior intercondylar regions serve as borders for the intercondylar eminence, which is formed by these tubercles [37].

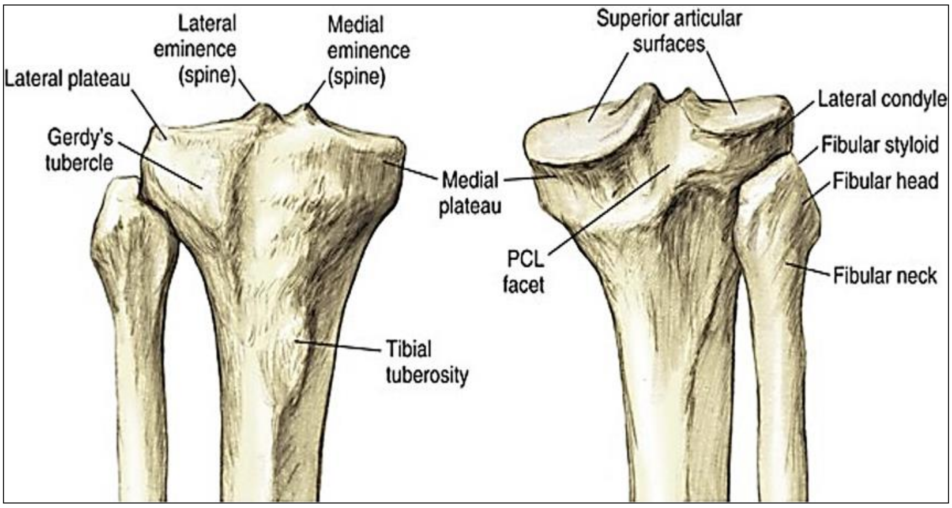

Fig 1: Bourne *et al*. (2024) adopted the proximal end of the tibia.

2. Biomechanics

The full-length AP standing radiograph is used to identify the mechanical axis of the lower leg. The middle of the tibial plafond (ankle joint) and the center of the femoral bead (hip joint) are the points where the axis passes. It is important that the mechanical axis aligns medially with the knee joint's midline. Millimetres are used to quantify the mechanical axis deviation (MAD) towards the side or medial of the joint relative to its center. On the full-length AP radiograph, the lower limb's anatomic axis is assessed by measuring the anatomic tibiofemoral angle, which is the upper acute angle generated by the femur and tibia [24].

Kinematics of the shin

The tibia, the body's second-largest bone, plays a crucial role in the leg by supporting the weight, with the medial portion of the tibia taking the brunt of that responsibility. Additionally, eleven muscles that enable dorsiflexion and plantarflexion at the ankle joint and extension and flexion at the knee joint originate from or enter into it [9].

Flexion and extension are the primary motions of the knee, which is essentially a hinge joint. At the knee joint, however, the femur and tibia have different articular surfaces in terms of radius and length. In comparison to the lateral condyle, the articular surface of the medial condyle of the femur is larger. The final 30 degrees of knee extension include a complicated action that involves "sliding" and enables the knee joint to move smoothly by rolling between the two bones. The cruciate and collateral ligaments constrict to support the knee joint when it is somewhat hyperextended at terminal extension [33].

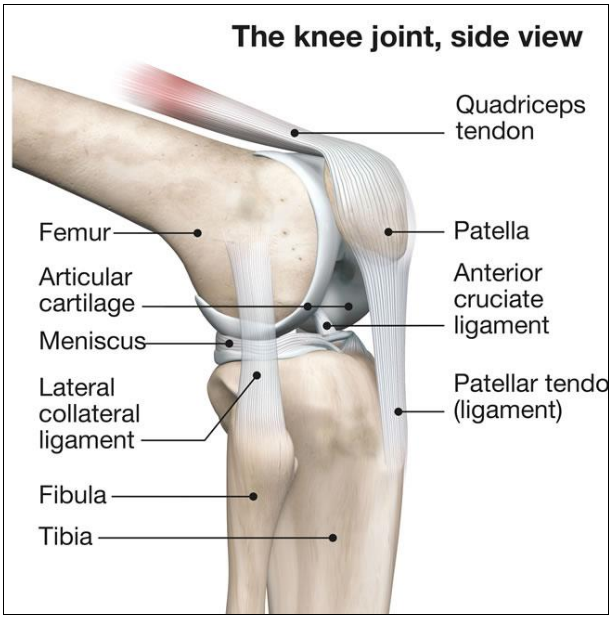

Fig 2: Standring's knee joint, as described by [32].

As The tibia rotates externally on the femur around 15° during the final 20° of extension due to the fact that the medial femoral condyle is longer than the lateral condyle. According to [17], this kinematic phenomenon is often referred to as the screw-home movement.

What causes the motions is not the form of the condyles. The leg extension machine and other open chain exercises cause the tibia to spin externally, a motion known as tibial-on-femoral rotation. Rotation of the femur on the inside of the tibia, as in a squat or other closed-chain movement. The anterior rolling of the tibia when the knee extends lengthens the posterior cruciate ligament (PCL), which in turn causes the pull-on tibia of the PCL to slide anteriorly. As the knee bends, the tibia glides posteriorly due to the pull of the ACL, which in turn lengthens the ligament. Using open chain movements, popliteus releases the kneecap. [13] found that when the hips rotate externally, it releases the knee by closed chain movements.

One of the most important components of stable knees that allow one to stand upright is the "screw-home" mechanism. In the swing phase, the tibia rotates internally, and in the stance phase, it rotates externally. A locked knee is the consequence of external rotation, which happens at the very end of knee extension and causes the anterior and posterior cruciate ligaments to tighten. At this point, the tibia is as stable as it can be relative to the femur. The last 30 degrees of extension bring the knee joint into a closed-packed condition by causing the femur to rotate medially on the tibia. The femur's lateral rotation releases the knee joint. During the final five degrees of extension, the Tibia lateralises on the Femur to create locking in the open kinematic chain. Medullary rotation unlocks. In terms of the amount of force that reaches the knee's cruciate ligaments, the tibial shear force is crucial. The three primary contributors to this force are the ground response force, the action of the knee muscles, and the contact force between the femur and tibia [32].

The sagittal plane's posterior slope of the tibial plateau causes an anteriorly directed shear force on the tibia, which is created by the tibiofemoral contact force. As you go about your day, this anterior shear force could build up to a significant amount. The shear force generated by the tibiofemoral contact force, for instance, is comparable to that of the ground response force and the knee muscles while one is walking [38].

The Knee's Role

The anterior and posterior cruciate, as well as the medial and lateral collateral ligaments, are among the several ligaments that support the knee. These do double duty: providing structural support for the knee and limiting its mobility. The knee joint must continuously absorb and cushion a variety of pressures to avoid the development of pathological strains because of its position within the human skeleton and because humans are bipedal. The medial and lateral menisci, located between the femur and tibia's articular surfaces, serve to absorb impact on the joint and provide a protective cushion for the knee [29].

The knee is a common site for muscle attachments. A number of them are essential for dynamic knee stability, even though they may not be directly involved in knee movement on a gross level. Above the patella, in a group of muscles called quadriceps, you may find the rectus femoris, vastus lateralis, intermedius, and medialis. The patella and the quadriceps are able to stretch and stabilize the knee in motion because of the patella ligament [8].

Biological or Leg mechanical axis

The diaphyseal midline of the tibia and femur is in line with their anatomical axis. The femur's mechanical axis extends from the knee's midpoint to the femoral head's center. The Mikulicz line, also known as the mechanical axis of the leg, runs from the ankle joint's central point to the femoral head's center. The average distance this line travels from the center of the knee joint to the medial side is 4 (± 2) mm. A valgus or varus deformity is indicated if the mechanical axis runs medial or lateral to this position [24].

Functional biomechanics in disease

The knee joint experiences the most stress compared to all other joints. The cyclical and repetitive motions of walking are associated with knee osteoarthritis. Bone remodelling occurs as a result of microdamage in the subchondral bone caused by mechanical stress. The bone's ability to absorb stress is diminished as a result of this remodelling, which increases its density. The result is a gradual degeneration of the joint cartilage due to the ever-increasing dynamic pressures [35].

The deviation of the mechanical axis, which impacts joint contact pressures, is affected by the distance between a deformity and a compensating joint. The subtalar and hip joints work together to compensate in the frontal (coronal) plane. Because of its inability to adjust in this plane, abnormalities in the distal femur or proximal tibia cause the knee to deviate significantly from its normal axis and experience elevated contact pressures in the joints. Even though a deformity close to the ankle or hip joints does not cause a big axis deviation, it does alter the angle of those joints considerably [19].

As a result, the contact area decreases and the contact pressure increases. So, abnormal knee contact pressures result from a deformity close to the knee, and abnormal ankle contact pressures result from a deformity close to the ankle. If your legs aren't the same length, your body will try to compensate by reducing the amount of vertical movement it does while walking. This will help you conserve energy. A proper range of motion and strength at each joint are necessary for these mechanisms, which include pelvic tilt, knee flexion, and ankle equinus. Symptoms such as patello-femoral pain and low back pain have been reported [30].

Damage to the lower extremities and their effects

Forces cannot be transmitted evenly at the knee joint when there are tibial or femoral irregularities in the frontal plane. The medial or lateral compartment is where mechanical stress and nonphysiologically load distribution take place instead. Cartilage damage and the onset or acceleration of degenerative joint disease are both correlated with mechanical overload in a joint compartment. Prearthritic deformities are defined as those that affect the lower extremities [31].

The distribution of pressure and the load balance at the knee joint are significantly affected by proximal tibial osteotomies. Restoring the knee's physiological axis and treating varus and valgus are both addressed by well-established techniques known as open wedge and closed wedge osteotomies [27].

A genu varum is defined as a joint where the lateral angle between the femur and tibial diaphysis (aFTA) is larger than 173˚-175˚.In the event of a notable varus misalignment, the mechanical axis deviation (MAD) from the knee joint's center will exceed 15mm medially, as the weight bearing line extending from the femoral head's center to the upper ankle joint's midpoint is more than 4 (± 2) mm medial to the knee joint's center. A larger gap (intercondylar distance) opens up between the two ends of the femur [46].

Management

Preoperative work up for osteotomies around the knee begins with a thorough patient history and physical examination. We pay close attention to things like career and athletic history, as well as any history of trauma or surgery. One must take into account the anticipated amount of patient activity. It is important to rule out contraindications such as nicotine addiction, which may cause the osteotomy to take longer to heal, being overweight, having rheumatoid arthritis, or being in the 60-70 age group, when knee arthroplasty yields better outcomes. But chronological age is less important than biological age [49].

The skin, muscles, veins, and arteries of the lower limb are all part of the clinical examination. An infection, either systemic or local, has to be eliminated [7].

It is required that the knee have a range of motion of at least 120˚ in flexion and no more than 20˚ in extension. Leg length, as well as anteroposterior and mediolateral ligamentous stability, should be checked. Under full weight bearing and while supine, the alignment of the lower extremities is assessed. Varus stress causes painful movement when the medial compartment is implicated, but valgus stress should alleviate that discomfort [25].

Aerial pictures

A weight-bearing x-ray of the whole lower limb as well as three-plane radiographs of the knee joint (anterior, lateral, and patella tangential views) are required for preoperative anatomy and leg axis evaluation. When considering an osteotomy around the knee, it is vital to have a weight-bearing x-ray of the leg taken to determine the appropriate indication [16].

The patient is asked to stand on both legs while an x-ray beam is horizontally focused during the test, which is done in AP projection. To prevent malrotation, make sure the patella is aligned with the front of the femoral condyles. Although they are not strictly required, weight bearing x-rays taken with the knee bent at a 45˚ angle, also known as the Rosenberg view, may provide insight into the extent of the alterations and the collapse of the joint, as well as the narrowing of the joint space in the afflicted compartment [34].

Genu varum therapy

Traditional medicine

Physical therapy and weight training may help strengthen the muscles around bones for mild instances that don't cause much discomfort. Nevertheless, the bones will not be straightened.

The surgical Methods

In younger adult patients, a high tibial osteotomy is the most frequent surgical procedure used to treat varus knee without substantial osteoarthritis. The tibia is realigned during this treatment by manipulating the bone via incisions. Closed wedge osteotomy, open wedge osteotomy, dome osteotomy, progressive callus distraction, and chevron osteotomy are some of the HTO procedures that are available [33].

Osteotomies around the knee are a well-respected way to address varus or valgus deformity that comes with unicompartmental osteoarthritis. Since the eighteenth century, osteotomies have been performed. When a knee osteotomy is performed, the lower extremity's weight-bearing axis is changed. Reducing discomfort, slowing degeneration, and delaying joint replacement are all goals of slightly overcorrecting onto a valgus or varus axis in order to unload the injured compartment and shift the weight burden away from the problematic parts [25].

Proper preparation, after a thorough patient evaluation, is crucial for a successful osteotomy. To get a decent outcome, you may employ a bunch of different methods [21].

Osteotomy Level: The highest point of the deformity is the optimal location for the procedure. The outcome will be the best possible adjustment. A new deformity will be created instead of the physiological axis being restored when an osteotomy is performed at a different level. When it comes to lengthy bones, the area with the most potential for healing is the metaphysis. At the diaphyseal bone, healing is drastically slowed down [6].

In comparison to closed-wedge osteotomies, open-wedge osteotomies are often less invasive and need less precision during surgery. In addition, the opening process permits intraoperative tuning by spreader adjustment of the opening.

Using angular stable implants usually eliminates the need for bone grafting. In order to get a satisfactory outcome, it is essential to restore or maintain the horizontal joint line, also known as the midjoint line [18].

A Miniaci planning method: It is possible to create the preoperative sketch when the osteotomy type and localization have been determined. Either a digital workstation or a weight-bearing x-ray of the leg may be used for this. The literature describes many ways for designing an osteotomy. A method to determine the corrective angle has been devised by [20] drawing on research by Fugisawa *et al*. and the planning approach detailed by Miniaci.

The adjustment angle was determined by [11] using the weight bearing line (WBL). The first line is the widest part of the tibial plateau (WBL), which extends from the hip center to 60-70% of the width of the tibial plateau, beyond the ankle. The second line goes all the way to the ankle's midpoint, following the hinge [14]. The hinge point of the osteotomy is joined to the arc junction of the first line by the third line. The proposed adjustment angle (x) is created by the second and third lines [11].

The risk of overcorrection or extreme joint line obliquity increases when just the femoral or intra-articular deformity is taken into account in a partial deformity study. It is possible to reduce the likelihood of these kinds of mistakes by including manual or semiautomated digital measurements into preoperative planning according to the Miniaci approach. Methodology Summary The angles may be automatically defined using PeekMed software by using landmarks at the proximal femoral side, distal condyles, proximal tibial plateau, and talus boundaries. After the weightbearing line is defined, the Fujisawa point is calculated to be half of the proximal tibia's length, and the Miniaci technique is used. According to [15], the approach may be either done manually or semiautomatically using the software.

Fig 3: The Miniaci procedure, often known as AO, is used for knee osteotomies.

It is common practice to treat unicompartmental knee osteoarthritis with proximal tibial osteotomy, often known as high tibial osteotomy. Five years following osteotomy, the majority of studies indicate that around 80% of patients are satisfied with the outcomes. A prevalent kind of joint deformity, varus or valgus causes an uneven distribution of the pressures that a joint must endure. A varus posture is the most prevalent deformity in people with osteoarthritis of the knee. This position causes the joint to be medially compressed, which speeds up the degenerative processes in that area. Osteotomy is a procedure that corrects the knee's alignment and unloads the joint compartment in order to equalize the knee's stress [45].

Arthroscopic evidence of fibrocartilaginous repair has been reported by several writers. According to a study by [15], fibrocartilage partially or completely covered eburnated lesions in 55% of patients, and only three out of 58 knees showed no indications of repair.

Occipital Osteotomy

The fibula was approached using a conventional postero-lateral technique, with care taken to avoid injuring the peroneal nerve, at the level of the fibula's proximal and middle thirds junction. The proximal tibia was cut using an anterior-medial longitudinal incision. To safeguard the soft tissues, retractors were positioned posteriomedially and posteriolaterally, and the tibia's periosteum was raised [23].

In the metaphyseal bone, the osteotomy level was found immediately distal to the tibial tuberosity. After drilling its crescent plane, the tiny osteotome was used to perform the osteotomy. The patient underwent angular and rotational correction using a dome-shaped osteotomy. Using intraoperative measurements of the knee joint lines, they were able to accomplish an overcorrection of 5° of valgus. [12] described reproaching the periosteum over the osteotomy and closing the skin and subcutaneous tissue.

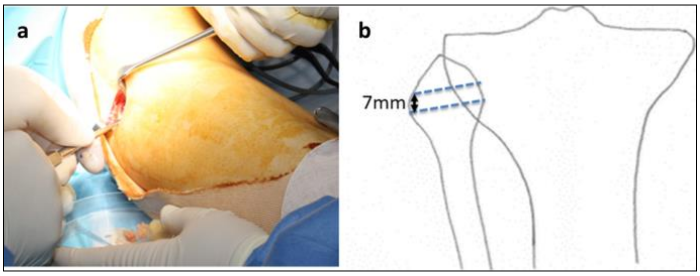

Fig 4: Osteotomy with a Dome Shape: a) The fibular neck is exposed by making a skin incision about 3 cm in front of the fibular neck and then expanding it subcutaneously. B) A 7-millimeter-high section of the fibular head that was 15 millimeters distal was removed. It was stated by [40].

Complications

Over as well as mechanical axis under correction due to limited intraoperative evaluation and poor preoperative planning. Injury to the bone's outer layer as a result of things like compartment syndrome, deep and superficial infections, hematoma, postoperative enlargement of soft tissues and lymph edema, deep crural thrombosis and pulmonary embolism, delayed closure of the osteotomy gap, and excessive pressure [4].

In summary

If the osteotomy of the proximal tibia is done within a certain range of deformity values, utilizing a defined procedure connected to a patented implant, it will provide favorable outcomes. A radically new method is necessary for the treatment of clearly visible varus malformations. Corrective proximal tibial osteotomies for genu varum need thorough deformity analysis for surgeons to pick the right patients. Because of this, we may take the deformity's size and other features into account, which will lessen the likelihood of technical issues that might develop from correcting the patient utilizing the suggested method in conjunction with a custom implant.

Conflict of Interest

Not available

Financial Support

Not available

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