Refining Growth Modulation: A Simplified Approach to Tension Band Plate Application

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ABSTRACT
Growth modulation using tension band plates (TBPs) is a well-established technique for the gradual correction of pediatric limb deformities. This study presents a refined surgical technique for TBP application designed to simplify the procedure while maintaining accuracy and safety. Key technical modifications include precise placement of guidewires using defined anatomical landmarks as references, the use of a minimal incision, and the incorporation of self-tapping screws to eliminate the need for pre-drilling. Clinical application of this modified approach reduces operative time, intraoperative fluoroscopy exposure, and surgical incision length while ensuring accurate TBP placement.
Keywords: Children; angular deformities; limb length discrepancy; guided growth; tension band plate.
Level of Evidence: IV

Perfeccionando el crecimiento guiado: un enfoque simplificado para la aplicación de placas de banda de tensión

RESUMEN
El crecimiento guiado mediante placas de banda de tensión es una técnica bien establecida para la corrección gradual de deformidades angulares en los miembros de los niños. Se presenta una técnica quirúrgica refinada para la aplicación de placas de banda de tensión, diseñada para simplificar el procedimiento manteniendo la precisión y la seguridad. Las modificaciones técnicas clave incluyen la colocación precisa de clavijas guía referenciadas a puntos de referencia anatómicos definidos, la utilización de una incisión mínima y la incorporación de tornillos autorroscantes para evitar la necesidad de utilizar una broca. La aplicación clínica de este enfoque modificado disminuye el tiempo quirúrgico, la exposición a la radioscopia intraoperatoria y la longitud de la incisión quirúrgica, al tiempo que garantiza una colocación precisa del implante.
Palabras clave: Niños; deformidades angulares; discrepancia de longitud de miembros; crecimiento guiado; placa de banda de tensión.
Nivel de Evidencia: IV

INTRODUCTION

Guided growth is a widely accepted method employing temporary hemiepiphysiodesis to correct pediatric angular limb deformities and address leg length discrepancies by leveraging the remaining growth potential of the immature skeleton. This approach is minimally invasive and reversible, offering distinct advantages over corrective osteotomies, including accelerated recovery, permission for immediate weight-bearing, and decreased overall morbidity. The fundamental principle is rooted in the observations of Hueter and Volkmann, who described the influence of mechanical forces on physeal growth.[1-3]

Historically, guided growth techniques evolved from early methods such as Phemister's open epiphysiodesis[4] and Blount physeal stapling[5]. These were subsequently refined with the introduction of percutaneous epiphysiodesis utilizing transphyseal screws (PETS) by Métaizeau.[6] A significant advancement occurred in the early 2000s when Stevens introduced the tension band plate (TBP).[7] This implant provided a more stable and predictable construct for temporary hemiepiphysiodesis, substantially reducing implant complications and the need for revi-

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sion surgery compared to physeal staples. Consequently, the TBP rapidly became the preferred device for guided growth procedures. Recognizing the potential for further optimization, Masquijo et al.[8] introduced initial refinements to the TBP application technique in 2015, improving procedural efficiency while maintaining accuracy and safety. These prior modifications were associated with reduced operative time, decreased fluoroscopy exposure, and smaller incisions while ensuring precise implant placement.

The purpose of this paper and the accompanying video is to provide a comprehensive, step-by-step description of the authors' preferred refined technique for TBP placement for the management of pediatric angular deformities and leg length discrepancies. This resource aims to serve as a valuable guide for orthopedic surgeons performing guided growth procedures in skeletally immature patients.

SURGICAL TECHNIQUE

The patient is positioned supine on a radiolucent operating table under regional anesthesia. The affected limb is prepared and draped in a sterile fashion to maintain strict aseptic technique throughout the procedure. A pneumatic tourniquet is applied to the proximal thigh and inflated to the appropriate pressure to provide a bloodless surgical field, thereby enhancing visualization.

Under fluoroscopic guidance, the initial guidewire is carefully inserted into the epiphysis. The trajectory is directed at approximately a 40-degree angle relative to the longitudinal axis of the bone, aiming toward the anatomical landmark of the femoral notch when operating on the distal femur. The precise distance between the guidewire tip and the distal femoral physis is determined by the size of the tension band plate being used. For example, when using a 20 mm TBP, which is commonly selected for the distal femur in adolescents, the guidewire should be positioned 10 mm distal to the physis. This position aligns with the spacing between the central and distal screw holes of the plate. The TBP is then temporarily advanced over the guidewire, and its position relative to the physis and the mechanical axis is assessed fluoroscopically in the sagittal plane. Once the optimal position is confirmed, the skin is marked with a surgical pen along the edges of the plate to create an external reference for alignment. The guidewire should be positioned as close as possible to the proximal margin of the distal screw hole to facilitate seamless screw placement after the plate is inserted through the small skin incision.

A second guidewire is then inserted into the metaphysis. This wire is placed divergent to the epiphyseal wire and oriented perpendicular to the femoral diaphysis in the coronal plane. Initial clinical assessment is performed to ensure both guidewires lie in the same sagittal plane and exhibit appropriate divergence (Figure 1).

Figure 1. Percutaneous placement of epiphyseal and metaphyseal guidewires. Note that both guidewires are positioned within the same sagittal plane but are divergent, ensuring optimal placement for guided growth modulation.

Fluoroscopic confirmation is then obtained to verify the correct spatial relationship and positioning of both guidewires relative to the physis and bone anatomy before proceeding with the incision.

The temporary guide plate is removed, and a small skin incision, typically measuring 2 cm in length, is made midway between the two guidewires. Blunt dissection is carefully carried down through the subcutaneous tissue to expose the periosteum. Meticulous effort is made to preserve the periosteum and the perichondral ring to minimize soft tissue disruption and avoid potential growth disturbance. The joint capsule, if encountered, is delicately opened to expose the bone surface without compromising the epiphyseal vessels. A tension band plate of the selected size (this plate is not used over the skin but is the implant for insertion) is then carefully guided over the two previously placed guidewires and seated flush against the bone surface. Two fully threaded 4.5 mm self-tapping screws are then inserted sequentially through the plate holes, following the trajectories of the guidewires. The epiphyseal screw is inserted first to secure the distal aspect of the plate to the epiphysis. Subsequently, the metaphyseal screw is inserted to stabilize the proximal aspect of the construct. The use of self-tapping screws eliminates the need for pre-drilling the screw holes, further streamlining the procedure. Final implant positioning is meticulously confirmed using C-arm fluoroscopy in both the coronal and sagittal planes. This ensures accurate plate alignment relative to the physis and mechanical axis, verifies stable fixation, and confirms that the screws have not violated the physis. The five essential fluoroscopic views required to confirm proper TBP placement are illustrated in Figure 2.

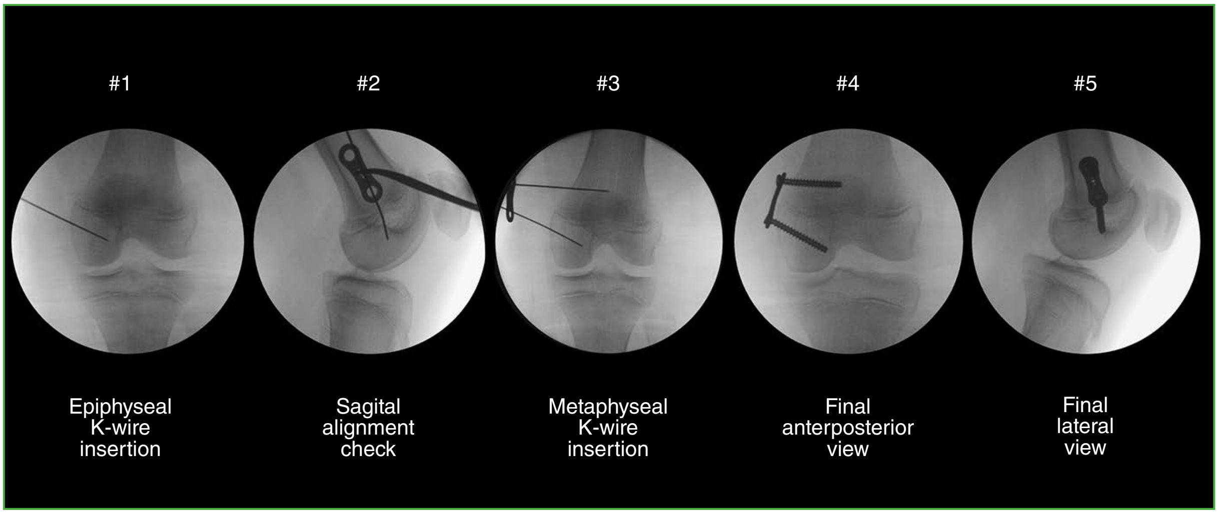

Figure 2. The five fluoroscopic views necessary for precise tension band plate placement, ensuring accurate positioning.

Following implant insertion and confirmation, the surgical site is thoroughly irrigated with sterile saline solution to remove any debris. Hemostasis is achieved, and the wound is closed in layers using absorbable sutures. A #2 Vicryl® suture is typically used for the subcutaneous tissue, and a #4.0 Vicryl® rapid suture is used for the skin closure. Sterile adhesive strips are applied over the incision, followed by a sterile dressing and a soft compressive bandage (Video).

Postoperatively, patients are permitted full weight-bearing and unrestricted range of motion of the affected limb as tolerated immediately following surgery. Follow-up clinical and radiographic evaluations are scheduled every three to four months to monitor the progression of deformity correction and to identify any signs of potential overcorrection, allowing for timely implant removal (Figure 3).

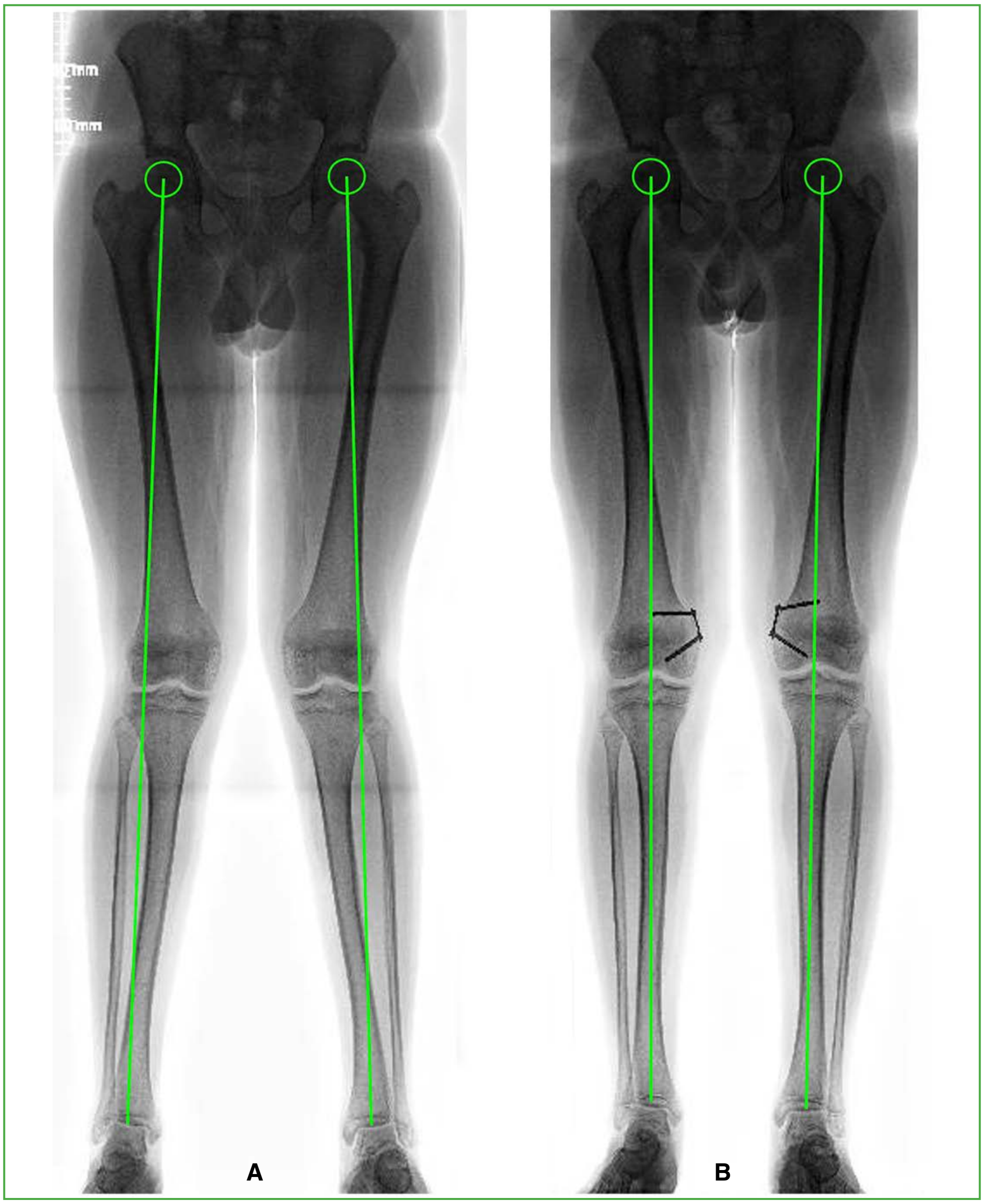

Figura 3. **A.** Preoperative clinical image of a 13-year-old boy with idiopathic genu valgum (zone 2), indicated for guided growth correction using tension band plates in the distal femur. **B.** Follow-up long-leg radiograph at 12 months demonstrating complete correction of the deformity.

DISCUSSION

Growth modulation using tension band plates (TBPs) has significantly advanced the management of pediatric limb deformities, providing a minimally invasive, highly effective, and reversible treatment alternative to osteotomies.[9] While the original technique described by Stevens[7] remains the foundation, continuous refinements to the surgical approach are pursued to further enhance procedural efficiency, minimize invasiveness, and reduce associated morbidity. The modified TBP placement technique presented here builds upon our prior work[8] by introducing specific technical optimizations designed to streamline key surgical steps, resulting in demonstrated reductions in operative time, intraoperative radiation exposure, and incision size while preserving implant accuracy. Our refined approach enhances TBP placement through several key modifications. The use of precise guidewire positioning, referenced to anatomical landmarks and verified with a limited set of standardized fluoroscopic views, improves the accuracy of initial implant trajectory planning. Minimizing soft tissue dissection through a smaller incision potentially contributes to faster recovery and reduced post-operative discomfort. The incorporation of self-tapping screws eliminates the need for the pre-drilling step, simplifying the procedure and further reducing operative time. Collectively, these modifications result in a more reproducible and efficient technique that maintains the biomechanical effectiveness of the tension band principle for guided growth.

A particularly significant advantage of our modified technique is the substantial reduction in intraoperative fluoroscopy usage. Traditional TBP application often necessitates multiple fluoroscopic checks at various stages to ensure proper guidewire and plate positioning, leading to increased radiation exposure. By optimizing guidewire placement based on anatomical cues and using a defined set of only five standardized fluoroscopic views for final confirmation, our technique effectively minimizes radiation. This is paramount in pediatric orthopedics, where minimizing exposure to ionizing radiation is a critical priority. Children are more susceptible to the detrimental effects of radiation due to their actively dividing cells and longer remaining lifespan, increasing the lifetime risk of radiation-induced malignancies. Furthermore, cumulative intraoperative radiation exposure poses significant occupational hazards for the surgical team, particularly to less shielded areas such as the hands and thyroid. Our method aligns with the ALARA (As Low As Reasonably Achievable) principle, enhancing the safety profile of the guided growth procedure for both the patient and all operating room personnel without compromising the precision or effectiveness of implant placement. The use of an external guidewire reference and verifying wire divergence prior to incision further contributes to accurate initial positioning, reducing the need for subsequent radiographic adjustments.

CONCLUSIONS

The refined technique for tension band plate application described herein represents an accessible, efficient, and reproducible alternative to standard TBP placement. The demonstrated advantages, including reduced operative time, decreased fluoroscopy exposure, smaller incisions, and maintained accuracy, offer benefits for both surgeons and patients while significantly enhancing surgical efficiency. As guided growth remains a cornerstone in the treatment of pediatric limb deformities, continued refinement of surgical techniques, such as the approach presented, will further optimize outcomes and improve the overall safety and efficacy of the procedure.

Conflicts of interest: The authors declare no conflicts of interest.

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