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Expanding the horizons of clinical applications of proximal humerus locking plates in the lower extremities: A technical note

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ABSTRACT

Pre-contoured anatomical locking plates were designed to address the clinical need of fixing small epiphyseal segments with a larger number of screws. Those plates match the contour and shape of a variety of bones allowing for optimal buttress properties. The aim of this manuscript is to highlight the benefits of applying proximal humerus locking plates in the fixation of lower extremity bones. Although designed for the proximal humerus, the low-profile plate shape and anatomic contour also provides versatile use in certain areas of the lower extremity. This technical narrative highlights the versatile and reliable use of this plate for other anatomical areas than the one to which it has been originally conceived.

Introduction

Anatomical plates were designed to match the anatomy of long bones. Unusual fracture patterns are becoming more frequent with the increase of high-energy trauma. For certain anatomical areas however or in patients with some peculiar characteristics like short stature or dysplastic bones, no specifically-designed implants are currently available for fracture fixation. Proximal humeral pre-contoured locking plates feature a low profile and fit properly several anatomic areas. Furthermore, this implant presents the advantage of several locking screws in different trajectories, which enhances the biomechanical properties of the bone implant construct, by increasing significantly the pull-out force needed to produce a mechanical failure. This implant can also be applied to medial condyle fractures of the femur, pediatric proximal and distal femoral fractures,[1–4] femoral fractures in post-polio patients, periprosthetic fractures around the knee, proximal and distal tibia fractures,[5,6] as well as hindfoot and ankle fusions[7–9] (Fig. 1, Table 1).

This case-based technical note aims to present the unconventional and versatile use of proximal humeral pre-contoured locking plates as an alternative in the management of unique clinical scenarios mostly present in orthopedic trauma.

Case presentations and review of the literature

Some areas of the skeleton, for example the medial aspect of the distal femur, are still lacking the development of dedicated anatomical locking plates. Fractures in this area may be a challenge to fix and may require the orthopedic surgeons to think out of the box adopting non-conventional approaches or fixation methods. Deciding for the right implant, the surgeon should take into consideration its biomechanical efficiency as well as how friendly is the hardware to the surrounding soft tissues. The proximal humeral pre-contoured locking plate fits very well to the medial femoral condyle and allows placement of several locking screws. However, it is important to highlight that

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Fig. 1. Synbone models with proximal humeral locking plates (LOQTEQ®, Berlin, Germany) applied in different anatomic areas. (A) and (B): Posterior surface of the distal tibia; (C): Medial surface of the distal tibia; (D) and (E): Posteromedial surface of the tibial plateau; (F) and (G): Medial condyle; (H-J): Pediatric hip in anterior, posterior, and lateral views respectively.

Table 1
Possibilities of unconventional use of proximal humeral locking plates in the lower extremity.

Fracture location	Indications
Proximal femur	(1) Pediatric subtrochanteric fractures
	(2) Fractures in abnormal bones when nail fixation is not an option (e.g. post-polio proximal femoral fractures)
Distal femur	(1) Fractures of the medial condyle
	(2) Complex bicondylar distal femur fractures (in association with a lateral distal locking plate)
	(3) Periprosthetic distal femur fractures with stable prosthesis (in association with a lateral distal locking plate)
	(4) Pediatric distal femur fractures
Proximal tibia	(1) Periprosthetic proximal tibia fractures
	(2) Complex tibial plateau fractures (especially in revision cases involving the medial tibial plateau, when a stronger construction is necessary)
Distal tibia	(1) Ankle fusion
	(2) Revision cases involving the posterior surface of the distal tibia

bicondylar fracture patterns with meta-diaphyseal extension are not adequately treated by using solely this implant, due to insufficient mechanical properties. Case 1 depicts the use of a pre-contoured locking humerus plate to treat a complex medial femoral condyle open fracture caused by gunshot injury (Fig. 2).

The post-polio femoral fracture is another interesting indication for proximal humeral locking plates. Post-polio syndrome usually evolves with severe osteopenia, muscular atrophy, and the distal femur is usually small, thin, and deformed.[10] Conventional lateral locking plates may be too large to treat this fracture pattern, thereby compromising construction stability and causing soft tissue discomfort. Case 2 depicts a subtrochanteric fracture in a 37-year-old post-polio patient who underwent fracture fixation with a proximal humeral locking plate (Fig. 3). X-ray evaluation after 5 months depicted an almost completely healed fracture with no postoperative complications.

However, we recognize that some fracture treatment principles should not be violated. First, fracture reduction is slightly in varus. Varus reduction is a major concern and must be avoided to decrease failure of fixation in pertrochanteric fractures. Moreover, unconventional use of pre-contoured proximal humeral locking plates in this situation should be considered as an exception. Considering an excessively high biomechanical stress in the pertrochanteric area, proximal humeral plate is not recommended to fix a standard pertrochanteric fracture due to insufficient mechanical properties.

Another issue is proximal femoral fractures in the pediatric population. Few implants designed for pediatric fixation exist, and they are not available everywhere. Shaw et al.[1] reported the use of a proximal humeral locking plate successfully treating a periprosthetic femoral fracture in an 18-year-old patient with cerebral palsy. The authors reported no postoperative complications and radiographic union was confirmed at 11 months. Gogna et al.[2] presented a case series of 8 subtrochanteric fractures using proximal humeral locking plates in patients of 13 years old on average

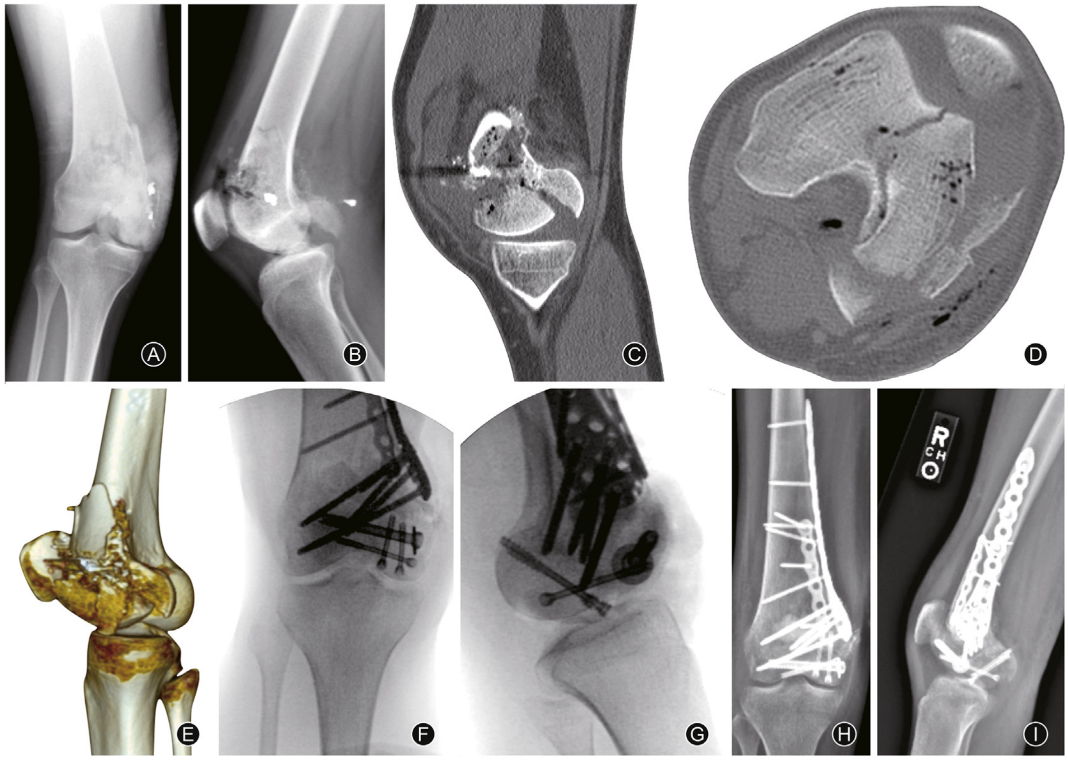

Fig. 2. Case 1: use of a pre-contoured locking humerus plate to treat a complex medial femoral condyle open fracture caused by gunshot injury. (A) and (B): Distal femur in anteroposterior and lateral views after a gunshot injury, presenting a comminuted medial condyle fracture. (C-E): Sagittal, axial, and 3D CT-scan reconstruction views showing a Hoffa fracture with diaphyseal and intercondylar involvement, medially. (F) and (G): Cannulated screws support the fixation of the articular components. A proximal humerus plate (AxSOS 3 Proximal Humerus, Stryker®) used upside down improves fixation and allows for locking screws crossing the fracture, therefore purchasing into the lateral condyle. (H) and (I): Anteroposterior and lateral views after healing, exhibiting a well-maintained joint line.

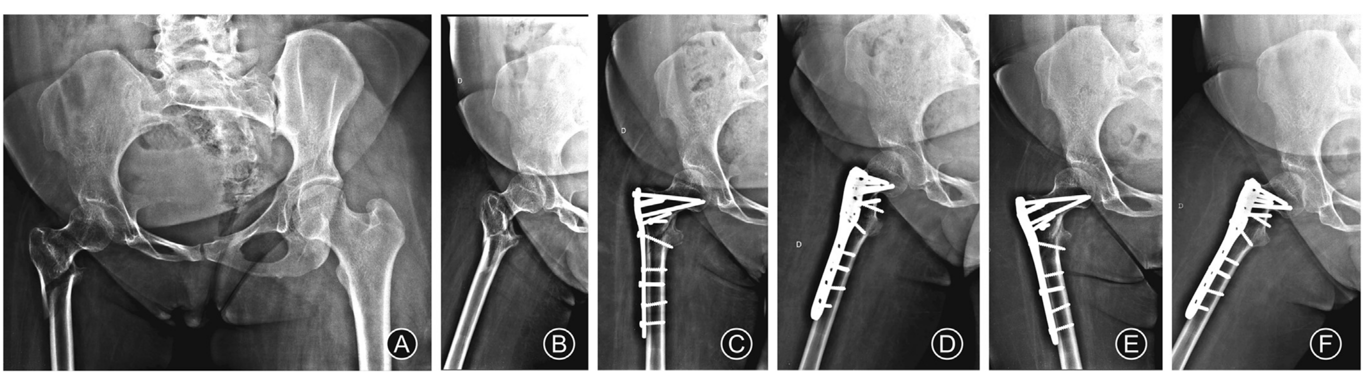

Fig. 3. Case 2: a subtrochanteric fracture in a 37-year-old post-polio patient who underwent fracture fixation with a proximal humeral locking plate. (A) and (B): Anteroposterior and lateral views showing the subtrochanteric fracture of the femur in a post-polio patient. (C) and (D): Radiographs in anteroposterior and lateral views showing fracture reduction and fixation with a proximal humeral locking plate (Philos plate, DePuy Synthes®). (E) and (F): Radiographs in anteroposterior and lateral views after 5 months showing fracture healing.

(10–16 years). The mean healing time was 8.75 weeks (6–14 weeks). Just one patient required implant removal due to prominent hardware in the proximal thigh near the trochanteric ridge. In one patient, implant was prominent in proximal thigh, requiring removal after 10 months.

Periprosthetic fracture around the knee represents another difficult situation. Poor bone quality, short metaphyseal fragments for fixation, and the prosthesis presence restricting the narrow area for screw placement are the main challenging obstacles for successful fracture fixation. More specifically addressing the distal femoral periprosthetic fractures, an expressive number of the fractures present a short lateral meta-epiphyseal fragment and a larger medial fragment. In this situation, we advocate the use of a proximal humeral locking plate medially buttressing the medial fragment and a long lateral distal locking plate to enhance the construct stability and allows for full immediate weight-bearing, essential for diminishing clinical complications in the elderly.[11] Fig. 4 depicts the treatment of a Rorabeck type II distal femur fracture (Case 3) treated with a medial proximal humeral locking plate associated with a long distal femur locking plate.

The current literature contains several studies addressing the posterior malleolus. A trend for rigid fixation with plate and screws exists, even for small fragments, depending on fracture location, morphology, and ligament stability.[12,13] Low profile plates such as

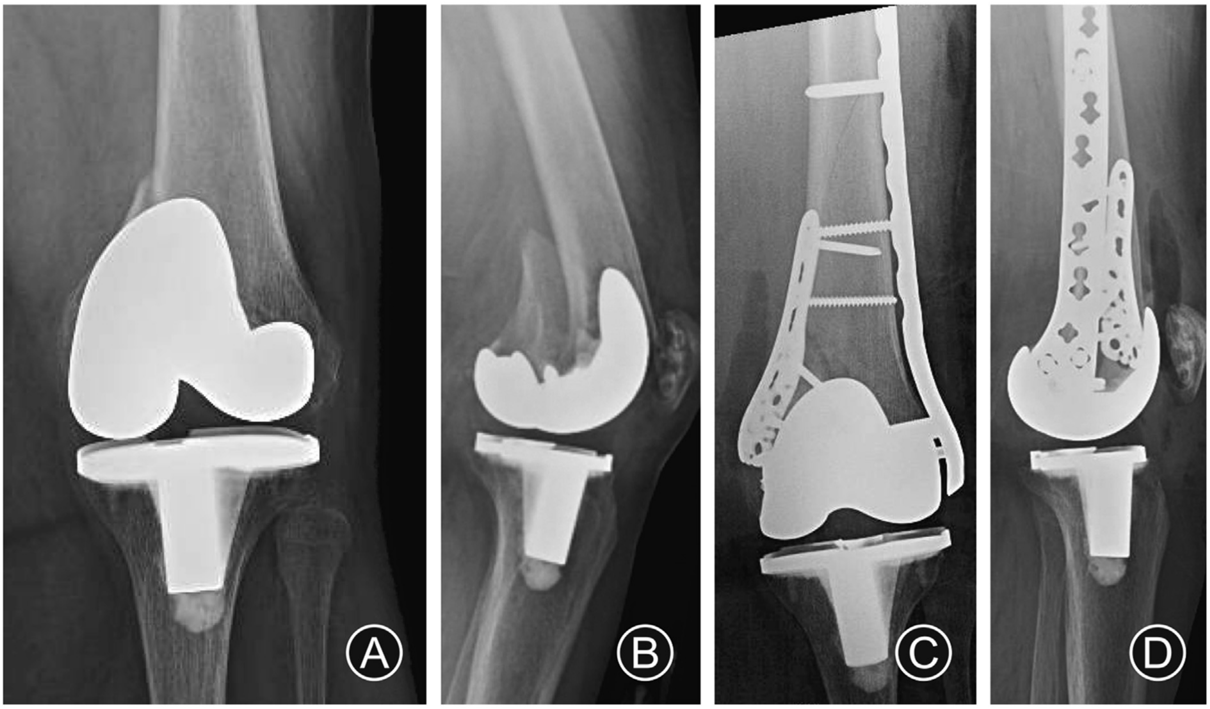

Fig. 4. Case 3: treatment of a Rorabeck type 2 distal femur fracture treated with a medial proximal humeral locking plate associated with a long distal femur locking plate. (A) and (B): Radiographs in anteroposterior and lateral views showing a distal femur periprosthetic fracture. (C) and (D): Radiographs in anteroposterior and lateral views depicting fracture fixation with a medial proximal humeral locking plate (Philos plate, DePuy Synthes®) associated with a long distal femur locking plate.

Fig. 5. Case 4: a primary ankle arthrodesis with a proximal humeral locking plate resting on the posterior surface of the tibia. (A) and (B): Radiographs in anteroposterior and lateral views showing a complex tibial pilon fracture with varus deformity. (C-E): CT-scan on sagittal, coronal, and axial views showing fracture comminution. (F) and (G): Radiographs in anteroposterior and lateral views showing ankle fusion with a posteriorly placed, upside down proximal humeral locking plate (Philos plate, DePuy Synthes®). (H) and (I): Radiographs in anteroposterior and lateral views showing ankle fusion.

the T-distal radius plate, one-third tubular plate, 2.4 mm or 2.7 mm locking plates, and specifically designed pre-contoured anatomic plates are the most commonly used implants to buttress the posterior malleolus. However, especially in revision cases involving malunion or nonunion, a stronger construct may be necessary to adequately buttress the posterior tibial surface. Our preference for revision cases is the pre-contoured proximal humeral locking plate used upside down to buttress the posterior surface of the distal tibia.

Some studies have described the non-conventional use of proximal humeral plates for ankle and hindfoot fusion. Deformities, poor bone stock, and poor soft tissue conditions are the main challenges for successful hindfoot and ankle arthrodesis. Several authors have advocated using proximal humeral plates for this procedure due to their low profile and multiple possibilities of locking screws to increase construction stability, thereby providing an adequate environment for healing.[7–9] Fan et al.[9] reported a case series of 12 patients who underwent tibiotalocalcaneal arthrodesis using a reverse proximal humeral locking plate with medial cannulated screw, resection of the distal fibula and bone graft. After a mean time of 18.6 months postoperatively (12–36 months), no cases of infection or skin necrosis were observed. After final follow-up, satisfactory fusion and axial alignment were obtained. Mean American Orthopaedic Foot and Ankle Society score average was 77.59.

Shearman et al.[8] retrospectively assessed the outcomes of proximal humeral locking plates in 21 patients who had undergone hindfoot and ankle fusions. The average follow-up was 14.6 (median 10, range 6–49) months. Eighteen patients (85.7%) achieved arthrodesis union at an average time of 4.8 (median 4.3, range 3–12) months. The incidence of deep infection was 14.3%. Seventeen of the 21 patients (81.0%) presented good to excellent clinical outcomes, 1 (4.8%) fair result, and 3 (14.3%) nonunion.

Case 4 was a 48-year-old patient who presented a complex pilon fracture. After 2 months awaiting soft tissue recovery, the ankle remained displaced, so we performed a primary ankle arthrodesis with a proximal humeral locking plate resting on the posterior surface of the tibia (Fig. 5).

It is noteworthy that using plates to fix fractures in areas where they were not designed for is a special issue. Although a soft-tissue friendly interface matters, knowledge of deforming forces and mechanical stress that the plate will undergo is mandatory to determine if the indication is appropriated.

In conclusion, proximal humerus locking plates are versatile implants that should be considered for a variety of orthopedic applications, and may be particularly worthy for anatomical areas or peculiarities that were not addressed yet by other implants. However, one can consider that the use of proximal humeral locking plates for these indications is still off label. Future studies with larger sample size and longer follow-up are needed to assess the real safety and efficacy of this technique.

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Ethical Statement

Approval was obtained from the Department of the Locomotor Apparatus Chamber at Federal University of Minas Gerais to conduct this study. Informed consent was obtained from all individual participants included in the study.

Declaration of Competing Interest

The authors declare that they have no conflict of interest related to this manuscript.

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