

## Review Article

## Retrograde traditional femoral or tibial locked intramedullary nails for distal femoral injuries

Chi-Chuan Wu\*

Department of Orthopedic Surgery, Chang Gung Memorial Hospital, Chang Gung University, Taoyuan, Taiwan

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## ABSTRACT

Recently, the use of retrograde locked intramedullary nailing has become an increasingly accepted treatment option for distal femoral injuries. A retrograde traditional femoral or tibial locked nail has sometimes replaced a standard supracondylar nail, which has biomechanical disadvantages and a high cost. To date, this modified technique has been reported in few articles, and the suitability and technical points of this method have not been well defined. The aim of this study was to review the related literature, compare the findings with the author's experiences, and then possibly clarify the role of retrograde traditional locked nails in the treatment of distal femoral injuries.

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## 1. Introduction

Although antegrade reamed locked intramedullary nailing is the gold-standard treatment for most of femoral shaft injuries (e.g., fractures, malunion, or nonunion), its use for treating distal femoral injuries has some disadvantages.<sup>1–6</sup> The femoral shaft (from the lower border of the lesser trochanter to the upper border of the condyle) can be evenly divided into five segments, and the distal femur is formed from the fourth and fifth segments (Fig. 1). The fourth and fifth segments are known as the infraisthmus and the supracondyle, respectively.<sup>3,7–10</sup> Clinically, it is difficult to stabilize the supracondyle by using an implant because of its characteristically thin cortex, wide marrow cavity, and uneven contour.<sup>3,6–12</sup> Biomechanically, antegrade locked nails used in this region may result in implant failure owing to large stresses with stress concentration.<sup>3,4,6,8–10</sup> Therefore, plate systems are the traditionally favored implants for the treatment of injuries in this region.<sup>1,13</sup>

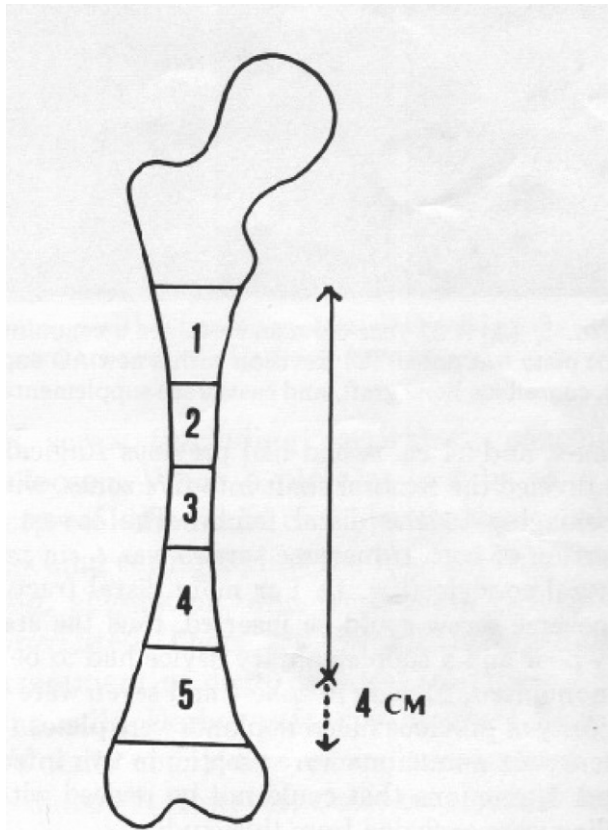
The traditional plate system consists of buttress condylar plates, dynamic condylar screws, and angled blade plates.<sup>1,13–17</sup> However, all implants have distinct advantages and disadvantages, and no implant has been demonstrated to be superior. In general, the

application of these plates requires open reduction of fragments, wide wound exposure, and extensive soft tissue dissection, which can lead to many complications.<sup>7,13,17</sup> Recently, minimally invasive percutaneous plate osteosynthesis (MIPPO) techniques have been introduced to improve surgical outcomes.<sup>18,19</sup> Furthermore, less invasive stabilizing system (LISS) plates combined with MIPPO techniques have been reported to be a successful treatment option. However, the learning curve for surgeons performing the technique cannot be neglected, as this could result in the occurrence of more serious complications.<sup>20–22</sup>

To improve the surgical approach, retrograde locked nails were developed. The earliest standard supracondylar nail was the GSH nail, which was designed by Green, Seligson, and Henry.<sup>23</sup> Since this nail is short in length, an image intensifier is not required for the insertion of locked screws at both ends of the nail. Therefore, supracondylar injuries can be treated relatively easily by using a closed technique.<sup>17,24–27</sup> However, the short length of the nail and the anterior bowing of the femur cause the nail tip to impact on the anterior cortex of the distal femur, which has a stress-riser effect.<sup>28,29</sup> Therefore, a second-site fracture of the femur may occur before the first-site fracture has healed. If a longer standard supracondylar nail is used, then an image intensifier may be necessary for the insertion of the upper locked screws. In addition, the standard supracondylar nail has a high cost. Therefore, a retrograde traditional femoral or tibial locked nail is sometimes used as a substitute to a standard supracondylar nail.<sup>30–32</sup>

\* Department of Orthopedic Surgery, Chang Gung Memorial Hospital, Chang Gung University, 5 Fu-Hsin Street, 333, Kweishan, Taoyuan, Taiwan. Tel.: +886 3 3281200x2423; fax: +886 3 3278113.

E-mail address: [ccwu@mail.cgu.edu.tw](mailto:ccwu@mail.cgu.edu.tw).



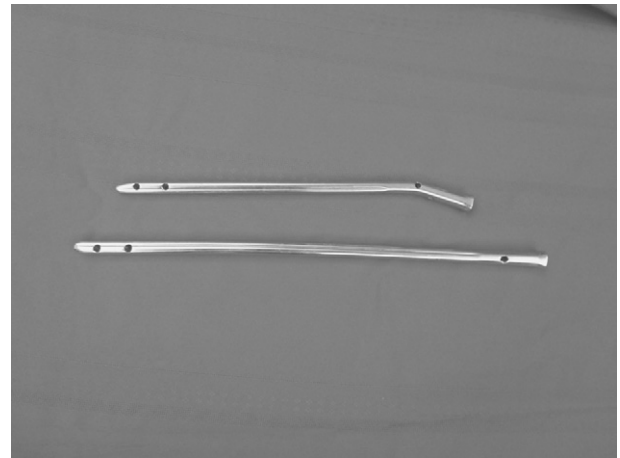
**Fig. 1.** The femoral shaft (from the lower border of the lesser trochanter to the upper border of the condyle) is evenly divided into five segments. The distal femur includes the fourth segment (the infraisthmus) and the fifth segment (the supracondyle).

However, this modified technique has been reported in few articles, and to date, the suitability of the method and technical points associated with it have not been documented in detail. The aim of this study was to review the related literature and compare the findings with the experiences of the author of this review. Then, possibly the functions of retrograde traditional locked nails used for the treatment of distal femoral injuries could be defined.

## 2. Biomechanical characteristics of retrograde traditional femoral or tibial locked nails

Traditional femoral or tibial locked nails can be used in a retrograde fashion. However, a traditional femoral locked nail may have more biomechanical advantages, since the femoral shaft is generally bowed anteriorly (Fig. 2). More extensive areas of traditional femoral locked nails make contact with the bone, which results in the transfer of more stresses, and thus, lowers the rates of implant and fixation failure.<sup>33,34</sup> In addition, the proximal part of a traditional tibial locked nail is acutely angulated at 20°. Therefore, fracture fragments in the supracondyle may be pushed away easily.<sup>34</sup> The shaft of a traditional tibial locked nail is relatively straight, which may make its insertion in the bowed femoral shaft difficult. Therefore, a retrograde traditional femoral locked nail may be more suitable than a traditional tibial locked nail for the treatment of femoral shaft injuries.<sup>34</sup>

If the fracture is located near to the locked screws in the nail head, then the nail holes and locked screws will be exposed to huge bending and torsional stresses; therefore, nail or locked screw breakage may occur (Fig. 3).<sup>4,35</sup> Protected weight bearing requirement must be undertaken.



**Fig. 2.** Traditional locked nails: (upper) a tibial nail with proximal angulation of 20°; (lower) a femoral nail with gentle anterior bowing.

## 3. Indications of retrograde traditional locked nails

In theory, retrograde traditional locked nails are suitable for the treatment of all femoral shaft injuries. However, to prevent a stress fracture, it has been recommended previously that the nail end should extend to the lesser trochanter.<sup>28,29</sup> Insertion of the upper locked screws may result in vascular injuries and requires an image intensifier, which further complicates the performance of the operation.<sup>36</sup> The upper locked screws may be unnecessary in transverse or short oblique mid-third shaft fractures, simple distal shaft fractures, and fractures that do not affect femoral length and stability.<sup>29,37</sup> In these cases, other devices, such as plates or staples must be applied (Fig. 4).

In the literature, the use of retrograde locked nails is recommended for obese patients, patients with bilateral femoral shaft fractures or ipsilateral femoral neck and shaft fractures, and patients with multiple injuries.<sup>17,37,38</sup> In these circumstances, using retrograde traditional locked nails to treat femoral shaft fractures can simplify the surgical procedure considerably.

Active femoral infection may be a contraindication of this technique. Nail insertion at the knee joint may induce knee pyarthrosis, which results in the treatment course becoming far more complicated.

## 4. Ideal inlet for retrograde traditional locked nails

The intercondylar notch, 5–10 mm anterior to the insertion of the posterior cruciate ligament and with slight medial adjustment, is the favored position for nail insertion.<sup>29,37,39,40</sup> Nail positioning may require slight forward or backward alterations according to the size of the bone and the type of nail used (femoral or tibial nail).<sup>34</sup> Since a tibial nail has anterior acute angulation of 20°, backward adjustment may be needed on insertion.

## 5. Complications related to techniques of retrograde traditional locked nailing

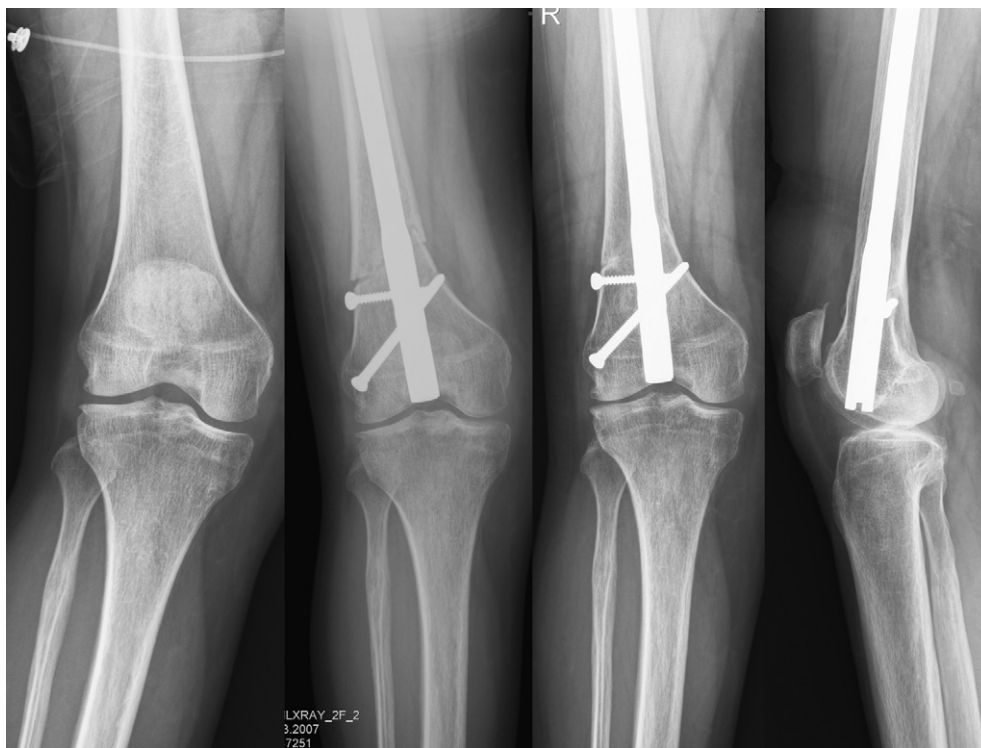
Retrograde traditional locked nail insertion has been associated with few complications, a majority of which are avoidable.<sup>17</sup> The subchondral bone is generally dense, and hence, 1-mm over-reaming is normally insufficient. A linear cleavage may occur in the regions surrounding the location of nail insertion (Fig. 5). Therefore, over-reaming of 2–3 mm in the nail inlet is generally required.<sup>41</sup> The nail head may protrude from the intercondylar notch and prevent smooth movement of the patella.<sup>17,42</sup> The jolty movement may heighten the patient's discomfort, leading to early removal of the nail.



**Fig. 3.** A 42-year-old male sustained a right femoral supracondylar nonunion after plating for 2.8 years. The nonunion was treated using a retrograde dynamic locked nail. Because the patient discontinued use of crutches, the nail broke at the site of nonunion after 8 months. Revision with a new retrograde locked nail and dynamic compression plate augmentation were performed. The site of nonunion healed uneventfully within 5 months.



**Fig. 4.** A 63-year-old woman experienced left femoral supracondylar nonunion for 2 years. Removal of the dynamic condylar screw, retrograde dynamic locked nailing, plate augmentation, and cancellous bone grafting were performed. The fracture healed within 4 months. At the 5.7-year follow-up, the patient had good knee function.



**Fig. 5.** A 52-year-old woman with a right knee deformity and a tibiofemoral angle of  $24^\circ$  valgus was treated. The knee deformity was treated with the technique described. A tibiofemoral angle of  $7^\circ$  valgus was achieved immediately after the operation. A cortical screw was used to treat the cortical splitting, which occurred during nail hammering. The osteotomy site healed at 4.0 months and an excellent outcome was achieved by the 4-year follow-up. The tibiofemoral angle at the latest follow-up was  $6^\circ$  valgus.

## 6. Clinical applications of retrograde traditional locked nails

### 6.1. Acute fractures

In principle, the retrograde traditional locked nail technique is suitable for all noncomminuted distal femoral fractures,

particularly periprosthetic fractures after total knee arthroplasty.<sup>17,37,43,44</sup> If the knee prosthesis is of the posterior cruciate-retaining type, then only a 5-cm knee wound is required.<sup>45</sup> The retrograde traditional locked nail is inserted in a dynamic fashion, and the patient is encouraged to ambulate with protected weight bearing as early as possible after the procedure. Thus, the treatment



**Fig. 6.** A 37-year-old man sustained a left femoral supracondylar fracture and was treated with antegrade locked nailing. Despite three operations, an aseptic nonunion still occurred for 15 months. The nonunion was treated with the described technique and was healed at 4.0 months. The patient had excellent knee function at the 4.5-year follow-up.





**Fig. 7.** An 80-year-old woman sustained a right femoral supracondylar fracture due to a ground level fall. Non-operative treatment caused a nonunion with severe osteopenia for 18 months. The nonunion was treated with the described technique. The fracture healed at 5 months and a good grade of knee function was achieved by the 4-year follow-up.

procedure is simplified. Dynamic mode nailing is accomplished by three-point fixation.<sup>46,47</sup>

There have been relatively few cases of knee infections following the insertion of standard supracondylar nails for the treatment of acute distal femoral fractures.<sup>48–50</sup> However, the use of retrograde locked nails for treating open fractures should be avoided if possible.

Knee function may decline after retrograde locked nailing.<sup>51</sup> However, in the experience of the author, knee function can be well preserved if complications that are related to surgical techniques are avoided.<sup>17,32,52,53</sup>

## 6.2. Nonunion or malunion

In principle, this technique is suitable for all distal femoral nonunions or malunions.<sup>32,52–54</sup> The approach is similar to that used for acute fractures, but adds the local procedure of debridement and a cancellous bone graft (Fig. 6). In the literature, simple exchange nailing is associated with a high failure rate.<sup>55,56</sup> Therefore, a cancellous bone graft is always imperative.<sup>52</sup> As much as 25-cc cancellous bone graft procured from the ipsilateral tibial condyle has been reported to be used.<sup>57</sup>

A dynamic compression plate may be used to increase local stability.<sup>32</sup> A high success rate is normally achievable if a cancellous

bone graft is used to fill gaps and initiate osteogenesis, and a nail and augmented plate are used to provide sufficient stability. For nonunion in an osteoporotic bone, nailing with partial bone cement and a partial cancellous bone graft may help achieve high success rates (Fig. 7).<sup>53</sup>

## 7. Comparison of retrograde traditional locked nails and standard supracondylar nails for distal femoral injuries

Although either traditional locked nails or standard supracondylar nails can be inserted in a retrograde fashion to treat distal femoral injuries, each type of nails has distinct advantages and disadvantages (Table 1). In principle, traditional locked nails may be considered initially. Standard supracondylar nails are recommended when the use of dynamic traditional locked nails alone do not provide sufficient stability, such as in cases of comminuted fractures or spiral fractures. Consequently, upper locked screws must be inserted, which then makes the performance of the procedure more complicated. Other devices may be used to increase stability, but they usually require an open wound to be created.<sup>32,41,52,53</sup> If a standard supracondylar nail is used, then the closed technique is generally successful. Thus, the surgical procedure is simplified to a great extent.

## 8. Conclusion

Retrograde traditional femoral or tibial locked intramedullary nails in a dynamic mode may be used for the treatment of distal femoral injuries. When local stability is insufficient, it may be increased through the use of plates, staples or bone cement. A cancellous bone graft procured from the ipsilateral tibial condyle is sufficient and convenient for use. The surgical technique is relatively simple, but the outcomes are still generally satisfactory.

**Table 1**

Comparison between retrograde traditional locked nails and standard supracondylar nails for distal femoral injuries.

Item	Traditional Locked Nail	Standard Supracondylar Nail
Cost	Low (350 USD)	High (2,000 USD)
Fixation mode	Dynamic (normally)	Static (normally)
Nail length	Long (generally)	Short (generally)
Augmentation	Often necessary	Usually unnecessary
Shaft stress fracture	No	Potential
Success rate	High	High

USD = United States dollars.

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