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# Retrograde femoral nailing of periprosthetic fractures around total knee replacements

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ABSTRACT

*Introduction:* The incidence of primary total knee replacement (TKR) is increasing with a resultant rise in those patients sustaining distal femoral periprosthetic fractures around TKRs. The management of these fractures pose a significant challenge. The compatibility of retrograde femoral intramedullary (IM) nails with femoral TKR components needs to be considered preoperatively when this complex pathology is addressed. The aim of this study was to update the literature and assess the compatibility of the most commonly used primary TKR prostheses and retrograde femoral IM nails using a Sawbone anatomical model.

*Methods and materials:* Eight of the most commonly used primary TKR prostheses and four of the most commonly used retrograde femoral IM nails were identified. The femoral components of the TKRs were implanted onto left sided femoral Sawbones using the manufacturer's guides and cutting blocks and positioned appropriately. The retrograde IM nails were inserted using the conventional entry point and a nail was deemed compatible if this was possible through the femoral prosthesis. Details of whether a posterior entry point was required to allow insertion, whether the femoral nail was scratched by the femoral TKR prosthesis on insertion and whether excess force was required to insert the retrograde femoral IM nail were recorded.

*Results:* The Biomet AGC Cruciate Retaining (CR) and Posterior Stabilised (PS) TKR were the only prostheses that were compatible with all the nails used. The other TKR prostheses were not compatible because of the force required to gain entry, scratching of the retrograde femoral IM nail or because a posterior entry point was required to gain entry through the intercondylar notch.

*Conclusion:* The majority of standard sized retrograde femoral nails are technically feasible for insertion through most femoral TKR components but this study has found that they are not compatible due to excessive force required for insertion, damage to the nail during insertion or the risk of anterior cortex perforation. Further studies are required to update the compatibility table and cadaveric studies would confirm the findings and allow further mechanical testing.



## Introduction

The management of femoral periprosthetic fractures around an existing total knee replacement (TKR) poses a significant management challenge. The population that sustain these fractures often have poor bone stock and osteopaenia. Instability of the fracture type and the risk of delayed fracture healing complicate surgical decision making [1]. The two main causes of supracondylar fractures around a TKR are iatrogenic and low energy trauma with the incidence ranging from 0.3 to 2.5% for primary TKR [2–8] and 1.6 to 38% for revision TKR [9]. Since one of the earliest published reports in 1981 [10], many treatment options have been proposed. Historically, these fractures were treated conservatively, with either casting, cast-bracing or with skeletal traction [2,10–13]. Minimally displaced fractures are still treated with non-weight bearing conservative management. However, the risks associated with these methods including the complications of prolonged immobility in bed, stiffness of the knee, malunion and nonunion, favouring surgical

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management. Surgical options include revision TKR with a long stemmed femoral component [2,14], open reduction and internal fixation (ORIF) with the use of buttress Plates [15,16], fixed angle devices such as the condylar screw plate and blade plate [15,17] and a Less Invasive Stabilisation System (LISS) [18,19]. In 1994, early reports were published advocating the use of a retrograde femoral intramedullary (IM) nail through the intercondylar notch of existing TKR [20,21].

Retrograde femoral IM nailing techniques offer potential advantages such as minimal soft tissue dissection, periosteal stripping and decreased postoperative stiffness. However, not all TKR prostheses are compatible with retrograde femoral IM nails as they do not afford the access to allow the IM nail to be passed through the femoral component and into the femoral canal, particularly in closed box prostheses. If access is theoretically possible, damage may be caused to titanium nails when they are passed through the prosthesis. Published reports over recent years have observed the compatibility of particular TKR prostheses with retrograde femoral IM nails; either by their theoretical compatibility due to the size of the TKR prostheses intercondylar notch size and location [22,23] or by the demonstration of a standard retrograde femoral IM nail passing into a Sawbone through the TKR femoral component [24]. As the incidence of primary and revision TKR increases, so will the number of patients presenting with this complex fracture pattern. Since the study of Currall et al. [24], new prosthesis designs have been introduced to the market. The aim of this study was to assess the compatibility of the most commonly used primary TKR prostheses and retrograde femoral IM nails for use in the management of periprosthetic fractures around TKR.

## Materials and methods

The 10 most frequently used primary TKR in the United Kingdom (UK) were identified from the National Joint Registry (NJR) [25] as well as a newly released TKR from one of the main device companies (Table 1) used by the senior authors' institution. A selection of commonly used retrograde femoral nails from different manufacturers (Table 2) were identified. The manufacturers were contacted to provide a sample of their prostheses for inclusion in the study. For each of the TKR prostheses femoral components, the distal end of a left sided femoral sawbone was prepared using the appropriate manufacturers' guides and cutting jigs and the femoral components positioned appropriately. Positioning of each femoral nail into the IM canal of the femur using the conventional entry point as specified by the manufacturers was attempted. If this entry point was not compatible, a posterior notch was made in the intercondylar region of the distal femur to allow the retrograde femoral IM nail to enter the IM canal of the femur through the intercondylar notch of the femoral component of the TKR prostheses. In this study, a posterior entry point was made by removing the posterior intercondylar notch of the femur so that the medullary canal could be accessed. A nail was deemed compatible if the retrograde femoral IM nail was positioned appropriately into the femur through the femoral prosthesis. Details including whether the nail was scratched by the femoral TKR prosthesis on insertion (Fig. 1), and whether excess force was required to insert the retrograde femoral IM nail were recorded. Excess force was defined as a force that in the opinion of the senior authors, would risk iatrogenic fracture, usually through the anterior cortex due to the posterior entry point and the bow of the retrograde femoral IM nail. Incompatibility of a nail was defined as a failure to physically pass the nail through the TKR femoral prosthesis, the requirement to use excessive force or significant damage to the IM nail including macroscopic scratches.

**Table 1**
TKR designs utilised in the study (these represent the 10 most commonly used models of knee (CR, CS and PS designs where appropriate) according to the National Joint Registry 2013 Annual Report and the newly introduced DePuy ATTUNE system. Where implants were not available from the manufacturer, these have been excluded.

| Manufacturer | Model | Included in study |
|---|---|---|
| DePuy | PFC Sigma CR | Yes |
| | PFC Sigma CS | Yes |
| | LCS Complete CR | Yes |
| | LCS Complete PS | No |
| | ATTUNE CR | Yes |
| | ATTUNE PS | Yes |
| Stryker (Stryker UK Ltd, Berkshire, UK) | Scorpio CR | Yes |
| | Scorpio PS | No |
| | Triathlon CR | Yes |
| | Triathlon PS | No |
| | Kinemax | No |
| Zimmer (Zimmer Ltd, Swindon, UK) | Nexgen | No |
| Biomet | AGC CR | Yes |
| | AGC PS | Yes |
| | Vanguard CR | Yes |
| | Vanguard PS | No |
| Smith & Nephew | Genesis II CR | Yes |
| | Genesis II PS | No |
| Endo Plus (Endo Plus UK Ltd, Swindon, UK) | Endoplus Bicondylar | No |

**Table 2**
Retrograde femoral intramedullary nails used.

| Manufacturer | Model | Diameter (mm) |
|---|---|---|
| Biomet | Phoenix retrograde nail | 10.5 |
| DePuy | ACE retrograde femoral nail | 10 |
| Smith & Nephew | Trigen retrograde femoral nail | 10 |
| Stryker | T2 supracondylar femoral nail | 10 |

## Results

Seven of the 10 most commonly used TKR prostheses were obtained from the manufacturers, as well as the recently released ATTUNE knee prosthesis (DePuy Synthes UK, Leeds, UK) (Table 1). Four commonly used retrograde femoral IM nails (Table 2) were used in the study. The compatibility of these nails with the 8 TKR prostheses is shown in Table 3.

Only the DePuy PFC Cruciate Stabilising (CS) TKR was not technically compatible with all the retrograde femoral IM nails due to its closed box design. However, several TKR required some force,

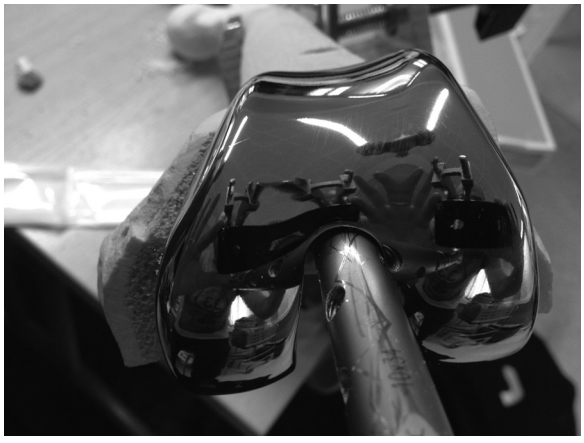

**Fig. 1.** Example of the scratches sustained to the retrograde femoral intramedullary nail on insertion through the femoral TKR component.