ORIGINAL ARTICLE

Arthrodesis in septic knees using a long intramedullary nail: 17 consecutive cases


Department of Orthopaedic Surgery and Trauma, Maison-Blanche Hospital, Reims Teaching Hospital Center, 45, rue Cognacq-Jay, 51092 Reims, France

Accepted: 11 March 2013

KEYWORDS
Knee;
Arthrodesis;
Intramedullary nail

Summary
Background: Intramedullary nailing using long or modular nails is the most reliable mean of achieving femorotibial fusion. Here, we report the operative, clinical, functional, and radiological outcomes of 17 long intramedullary nail arthrodeses in patients with infection.
Hypothesis: Clinical and functional outcomes after long intramedullary nailing are at least as good as those obtained using other implants.
Materials and methods: We retrospectively reevaluated 17 patients after unilateral two-stage knee arthrodesis with a long titanium intramedullary nail and autologous bone grafting. We evaluated satisfaction, leg length discrepancy, and function (Lequesne and WOMAC indices). Radiographs were obtained to assess fusion, time to fusion, and femorotibial angles.
Results: No cases of material failure were recorded. One or more complications occurred in seven patients. Mean limb shortening was 27.6 mm. Of the 17 patients, 15 were satisfied with the procedure. The mean Lequesne index was 10.5/24 and the mean overall WOMAC score was 26/88. Fusion was achieved in 16 patients, with a mean time to fusion of 5 months. Mean femorotibial angles were 178.6° of varus and 1.9° of flexion.
Discussion: This simple and rapid surgical technique provides functional outcomes similar to those obtained using modular nails. The fusion rate is high. Nail extraction is simple and causes minimal damage, in contrast to modular nails. Increased attention to misalignment is needed.
Level of evidence: Level IV, retrospective study.
© 2013 Published by Elsevier Masson SAS.

Introduction

When the condition of the knee or general health of the patient constitutes a major obstacle or a contraindication to total knee arthroplasty, knee arthrodesis is an alternative to amputation [1]. Knee arthrodesis is a demanding technique associated with a complication rate of nearly 40%

* Corresponding author.
E-mail address: leroux.bertrand.02@gmail.com (B. Leroux).
Many knee arthrodesis techniques are available including screw fixation, tibiofemoral screw-plate fixation [3,4], external fixation, and intramedullary nailing. Among them, the most widely used at present are nailing and external fixation. Intramedullary nailing has emerged as the most reliable method, notably in terms of higher fusion rates and shorter fusion times [2, 5]. The long intramedullary nail is introduced in the antegrade direction through the trochanteric region [6–8]. Despite the high fusion rate and relatively short fusion time, the difficulties with long-nail introduction and locking, combined with the risk of limb misalignment, lead many surgeons to prefer shorter pre-contoured [9] or modular [10–13] nails introduced through the knee. In our department, we previously used modular nails. However, removing these nails (for instance in the event of recurrent infection) either caused severe tissue damage or proved impossible. Consequently, we now use a long femorotibial nail.

Our hypothesis was that long intramedullary nailing performed using our surgical technique provided clinical, functional, and radiological outcomes that were at least as satisfactory as those obtained using other implants.

**Material and method**

**Patients**

We retrospectively reviewed 17 consecutive patients who underwent knee arthrodesis using long intramedullary nailing at our institution, between April 2010 and November 2011. The 12 men and five women had a mean age of 68.7 years (range, 40–85 years; median, 71 years) at the time of the knee arthrodesis.

Mean follow-up was 16 months (median, 15 months). At last follow-up, mean age was 70.1 years (range, 41–86 years; median, 73 years). In all 17 patients, the reason for arthrodesis was knee infection (infected total knee arthroplasty in 15 patients and septic arthritis of the native knee in two patients).

**Operative technique**

Knee arthrodesis was performed in all 17 patients by the same senior surgeon using the Stryker T2 long intramedullary nail (Stryker Trauma GmbH, Schönkirchen, Germany). This antegrade, hollow, cannulated nail with grooves but no cleft is made of Type II anodised titanium alloy (Ti6Al14V). Curvatures specific for the right and left limbs are available, as well as diameters of 11.5 and 13 mm and lengths ranging from 540 mm to 780 mm. The nail can be locked distally and proximally (in static or dynamic mode) using one or two latero-medial screws measuring 5 mm in diameter.

Before the arthrodesis procedure, the 15 patients with infected total knee arthroplasties underwent a first procedure for prosthesis removal and implantation of an antibiotic-impregnated acrylic spacer. The mean time from this first procedure to arthrodesis was 8 weeks (median, 9 weeks). The spacer was removed and debridement performed, with collection of bacteriological specimens, to prepare the bone extremities. The limb was placed in traction using a boot on a traction table. The nail was introduced through the greater trochanter. The appropriate nail length was determined intra-operatively as the length extending beyond the middle third of the tibial shaft. All nail lengths and diameters were available to the surgeon.

The nail was press-fit into the medullary canal with the foot in 5° to 10° of external rotation. Limb alignment was checked radiologically. The traction was released to achieve contact of the bone surfaces. The reaming debris and patellar bone grafts (two-thirds of the thickness of the patella) were used to fill the joint space. No bone substitute was implanted. The residual patella was left included in the quadriceps tendon, without fixation. Proximal locking was achieved using the specific tool. The first nine screws were locked in the dynamic position (oblong distal hole). The following screws were not locked distally.

A knee splint was worn for 6 weeks with partial weight bearing to ensure gradual compression of the knee.

**Clinical evaluation**

The clinical evaluation was performed by an independent surgeon. No patients were lost to follow-up. One patient died 18 months after the procedure, from acute heart attack.

The following data were recorded at last follow-up: pain in the operated limb or contralateral limb, use of a built-up shoe and/or canes, evidence of local infection (e.g., inflammation of the scar, dehiscence, sinus tract, or drainage) or systemic infection (e.g., fever, chills, sweats, or lymphadenopathy), and mobility at the knee. Leg length discrepancy was measured clinically and compared to the value obtained in the immediate post-operative period. Rotation was evaluated clinically.

Patient satisfaction was recorded as very satisfied, satisfied, somewhat dissatisfied or dissatisfied.

The Lequesne algo-functional index [14] and Western Ontario MacMaster Universities Osteoarthritis (WOMAC) index [15] were determined in 16 patients. For the WOMAC index, the stiffness domain was not assessed and the items were scored using a 5-point Likert scale (none, 0; mild, 1; moderate, 2; severe, 3; extreme, 4). The highest possible scores were 20 for the pain domain and 68 for the function domain, i.e., 88 for the total score.

Antero-posterior and lateral radiographs of the femur, tibia, and entire lower limbs were obtained to assess fusion, the femoro-tibial angle in the coronal plane, and the angle of flexion. Fusion was defined as a visible bony bridge between the femur and tibia.

**Results**

Table 1 reports the results.

**Complications**

One or more complications were recorded in seven patients:

- intra-operative fractures occurred in two patients: one was a tibial shaft fracture bridged by the nail and identified post-operatively and the other was a non-displaced...
### Table 1: Results.

<table>
<thead>
<tr>
<th>Patient Follow-up (months)</th>
<th>Healed Time to healing (months)</th>
<th>Cases</th>
<th>Shortening sites</th>
<th>Built-up (cm)</th>
<th>Lequesne index (°)</th>
<th>WOMAC Satisfaction index</th>
<th>Goniometric angle (°)</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>26</td>
<td>0 (–25mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
<td>26</td>
<td>0 (–25mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>Yes</td>
<td>25</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>Yes</td>
<td>24</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>Yes</td>
<td>23</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>Yes</td>
<td>22</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>7</td>
<td>Yes</td>
<td>21</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>8</td>
<td>Yes</td>
<td>20</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>9</td>
<td>Yes</td>
<td>19</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>10</td>
<td>Yes</td>
<td>18</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>11</td>
<td>Yes</td>
<td>17</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>12</td>
<td>Yes</td>
<td>16</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>13</td>
<td>Yes</td>
<td>15</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>14</td>
<td>Yes</td>
<td>14</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>15</td>
<td>Yes</td>
<td>13</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>16</td>
<td>Yes</td>
<td>12</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>17</td>
<td>Yes</td>
<td>11</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>18</td>
<td>Yes</td>
<td>10</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>19</td>
<td>Yes</td>
<td>9</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>20</td>
<td>Yes</td>
<td>8</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>21</td>
<td>Yes</td>
<td>7</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>22</td>
<td>Yes</td>
<td>6</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>23</td>
<td>Yes</td>
<td>5</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>24</td>
<td>Yes</td>
<td>4</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>25</td>
<td>Yes</td>
<td>3</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>26</td>
<td>Yes</td>
<td>2</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>27</td>
<td>Yes</td>
<td>1</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>28</td>
<td>Yes</td>
<td>0</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>29</td>
<td>Yes</td>
<td>0</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
<tr>
<td>30</td>
<td>Yes</td>
<td>0</td>
<td>0 (–20mm)</td>
<td>2cm</td>
<td>3</td>
<td>Very satisfied</td>
<td>20</td>
<td>None</td>
</tr>
</tbody>
</table>

Legend:
- Yes: Satisfied
- No: Dissatisfied
- Very satisfied
- Satisfied
- Somewhat satisfied
- Dissatisfied
- Very dissatisfied
- None
- Haematoma/Fibular nerve palsy
- Tibial fracture
- Recurrent fracture
- Haematoma
- Femoral fracture
- nerve palsy
- Varus
- Valgus
A femoral shaft fracture was identified intra-operatively. Both fractures were managed with elimination of weight bearing for 6 weeks. Time to fusion was comparable to that in the overall population;
- two patients experienced fibular nerve palsy, which resolved fully;
- post-operative haematoma developed in six patients, including one who developed skin necrosis requiring treatment with a medial gastrocnemius flap 3 months after the arthrodesis procedure;
- one patient experienced recurrent infection due to the same organism as initially, with a tibial sinus tract, and required removal of the nail; fusion was achieved and consequently no other implant was required.

Functional outcomes

Of the 17 patients, five were satisfied and 10 very satisfied. The mean overall WOMAC index was 26/88 (range, 17–48; median, 27). The mean WOMAC function score was 23/68 (range, 16–38; median, 24.5) and the mean WOMAC pain score was 3.4/20 (range, 0–10; median, 3.5) (Table 2). The mean Lequesne algo-functional index was 11/24 (range, 4–17; median, 11.5).

Sixteen patients reported no pain at rest or at night. Pain was reported during walking by 14 patients and during transfers by 15 patients. All patients had difficulties with squatting. One or two canes were required for walking in 13 patients. Walking distance was unlimited in one patient, 300 to 500 m in 10 patients, and 100 to 300 m in four patients. Finally, eight patients were unable to walk on uneven surfaces.

Clinical outcomes

Mean clinical limb shortening was 27.6 mm. Shortening was 30 mm or more in nine patients. Secondary shortening did not occur in any of the patients. Ten patients used a built-up shoe. Rotational deformities were noted in three patients.

Radiographic outcomes

At last follow-up, fusion was achieved in 16 patients with a mean time to fusion of 5 months (median, 4.5 months) (Fig. 1). The mean tibiofemoral angle was 178.6° (range, 176°–183°) and mean flexion was 1.9° (range, 1° to 3°).

Discussion

The complication rate (41%) and nature of the complications in our case-series are consistent with previous studies of knee arthrodesis using various intramedullary nailing techniques [16,17], long intramedullary nails [8], or modular nails [18]. All the complications were minor, whereas plate fixation has been associated with major complications (fatigue fracture and necrosis of muscle, bone, or skin) that often required surgical revision, removal of the material, or even amputation [3,4].

The two intra-operative fractures are probably ascribable to excessively vigorous and extensive reaming. None of the fractures prevented insertion of the nail. Both cases of fibular nerve palsy recovered fully within about 6 months, and the two patients reported being satisfied and very satisfied with the arthrodesis procedure, respectively.

Table 2  WOMAC index data.

<table>
<thead>
<tr>
<th>Patients</th>
<th>Pain</th>
<th>Function: difficulties with</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>When lying in bed/at night</td>
<td>When standing</td>
</tr>
<tr>
<td>Number</td>
<td>1</td>
<td>12</td>
</tr>
</tbody>
</table>

Please cite this article in press as: Leroux B, et al. Arthrodesis in septic knees using a long intramedullary nail: 17 consecutive cases. Orthopaedics & Traumatology: Surgery & Research (2013), http://dx.doi.org/10.1016/j.otsr.2013.03.011
In contrast to findings with other long nails, and although follow-up was limited in our case-series, none of the patients experienced breakage or migration of the material [8] and none of the locking screws required removal [9].

Extraction of a modular nail is difficult and causes substantial bone damage [18]. In contrast, long nails can be extracted easily and rapidly without causing loss of bone, a difference pointed out by Incavo et al. [19]. Removing a modular nail requires revision of the fusion to unscrew the various nail components. Extraction of these components frequently requires more or less extensive cuts in the femur and tibia, which result in substantial loss of bone tissue.

Many authors agree that recurrent infection is less common when the nail is inserted at a distance from the initial operative site and after normalization of the inflammation markers [1,9,11]. Except for a study by Letartre et al. [20], during which no recurrent infections were recorded, the recurrence rates were similar with modular nails (21% [18] and 14% [21]) and long nails (7% [7] and 10% [8]). We agree with Iacono et al. [21] that autologous bone grafting with no use of allogenic bone decreases the risk of recurrent infection. To date, recurrent infection developed in only one (6%) of our patients, but the follow-up is still short.

Satisfaction was usually good or very good, consistent with the greatest than 90% satisfaction rate reported with modular nails [12,20,21]. The mean Lequesne algo-functional index value was similar to those obtained with modular nails by Letartre et al. (12/24, [20]) and Iacono et al. (11/2/24, [21]). All the mean WOMAC score values were satisfactory; they were obtained using a Likert scale and are therefore difficult to compare with the visual analogue scale results reported by Bargiolas et al. [7] and Letartre et al. [20]. However, our finding that 94% of patients had no pain at rest and 58% no pain while walking are similar to the results in two studies of modular nails [20,21] and better than those obtained previously with long nails [6].

Mean limb shortening was 27.2 mm. Limb shortening is less marked with modular nails, as maintaining limb length is given priority over achieving compression. Volpi et al. [10], Neuerburg et al. [18], Letartre et al. [20], and Iacono et al. [21] reported shortening by 0, 15, 12, and 8 mm, respectively. However, shortening was less marked in our study than in previous studies of long nails (32 to 55 mm, [7,8,19]). This difference may be ascribable to our practice of routinely filling the joint space with reaming debris and patellar grafts before inducing compression.

Mean time to fusion was consistent with studies by Bargiolas et al. [7] using long nails and Nichols et al. [4] using plates. With long nails, autologous bone grafting, immediate dynamic locking of the nail, and compression via early weight bearing produce fusion rates of 89% or more [6,7]. Fusion rates with modular nails range from 85%—95% [11,13] to 68% [20]; the lowest rate [20] was achieved by authors who gave priority to maintaining limb length over achieving bone contact in patients with substantial bone loss.

With long nails, the angles of tibiofemoral valgus and flexion were 3.1° and 5.8°, respectively, in one study [19] and 1.3° and 5.5° in another [8]. In our case-series, the tibiofemoral angle was in varus and flexion was less than 2°. Loss of the physiological valgus angle may be ascribable to the patient installation with the leg secured to the traction table for the removal of the spacer and insertion of the nail (limited visibility for identifying the entry point at the proximal tibia). Pfung et al. [22] have suggested using navigation to avoid the malalignment and rotational deformities reported with long nails [19].

Conclusion

Although the fusion rate and time to fusion in our study are consistent with previous reports on intramedullary nailing for knee arthrodesis, the clinical and functional outcomes obtained using our technique compared favourably with those reported in studies of other long nails, and none of our patients experienced serious complications. The surgical procedure is rapid, requires no allogenic bone, and allows early weight bearing. The satisfaction rate and functional outcomes are similar to those described with modular nails, although mean limb shortening remains more marked. The ease of nail extraction, with minimal bone loss, is a valuable advantage, most notably in the event of recurrent infection. However, the surgical technique remains demanding, and there is still room for improvement, particularly regarding limb alignment and rotation.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References