Management of infectious fractures with “Non-Contact Plate” (NCP) method

Celil ALEMDAR, Ibrahim AZBOY, Ramazan ATICI, Emin ÖZKUL, Mehmet GEM, Ahmet KAPUKAYA

From the Department of Orthopaedics, Dicle University Medical Faculty, Diyarbakir, Turkey

The aim of this study was to evaluate the outcomes of internal fixation with Non-Contact Plating (NCP) after deep infection caused by previous surgeries of the tibia or femur fractures. The study included 15 patients (4 female and 11 male). The mean age patients was 36.6 years (range, 21-64 years). There were 6 femur and 9 tibia fractures. The mean follow-up period was 25.7 months (range, 15-45 months). The study comprised 11 open and 4 closed fractures. External fixator was used in 3, plate in 4, and intramedullary nail in 8 patients for index surgery. Deep infection was diagnosed via clinical findings, laboratory parameters, and microbiological evaluation. Deep infection was diagnosed within a mean period of 5.5 weeks (range, 2-10 weeks). The infecting organism was methicillin-resistant staphylococcus aureus (MRSA) in 5, methicillin-sensitive staphylococcus aureus (MSSA) in 6, pseudomonas auroginosa in 2, and enterobacteriacea in 2 patients. Union achieved in all patients. Mean time to union was 17 (range, 11-38) weeks. Delayed union was observed in 3 patients who required additional surgeries. Of these one patient developed osteomyelitis. The NCP is an effective alternative method in the treatment of deep infection encountered after internal or external fixation for the tibia, or femur fractures.

Keywords: infectious fracture; complication; internal fixation; locking plate; non-contact plate.

INTRODUCTION

Postoperative deep or superficial infection is still an important complication after surgical management of fractures of long bones. This complication was reported as 1-2% of closed fractures, and 1-50% of open fractures (11,19,25). Infection mostly results from iatrogenic and traumatic damage to the bones and soft tissues, avascular bone fragments, and the presence of virulent microorganisms in the fracture site.

The presence of infection makes the fracture more complicated as well as decreasing the effectiveness of standard internal fixation methods such as intramedullary nailing or plate-screw systems. This situation is largely associated with the relationship between infection and implant. In conventional methods, the implants allow a suitable environment for the microorganisms to create a biofilm (8,9). When the biofilm is formed, it becomes highly difficult to control the infection. Although antibiotic therapy and compression are suggested as ideal methods, the treatment of infectious fractures is...
further complicated with recurrence of infection, osteomyelitis and amputation (9). We hypothesized that the Non-Contact Plating (NCP) method which nearly eliminates the implant-bone contact might be helpful in the treatment of deep infection encountered after fractures of long bones.

In the present study, we evaluated the result of NCP method in the treatment of fractures of tibia and femur with deep infection after initial surgery.

**MATERIALS AND METHODS**

A total of 15 patients (4 female, 11 male; mean age 36.6 years [range 21-64 years]) treated with NCP method due to infected tibia or femur fractures between 2007 and 2012 who had adequate follow up were included. Patients with pathologic fractures, rheumatoid arthritis treated with corticosteroids for a long period of time, and inadequate follow-up were excluded. The OTA classification was used for fracture classification (Table 1) (10). There were 6 femur and 9 tibia fractures. Gustilo-Anderson classification was used for open fracture classification (Table 1) (7). The mechanism of injury was mostly traffic accident in 9 (60%) patients (Table I). External fixator was used in 3 (20%), plate in 4 (26%), and intramedullary (IM) nail in 8 (53%) patients for index surgery.

The symptoms for deep infection were accepted as pus, abscess formation, erythema, localized temperature growth, tenderness, and swelling (14). The diagnosis of deep infection was made on clinical findings, laboratory tests, and microbiological analysis of the samples obtained from deep tissue and bones. Culture and antimicrobial susceptibility tests were made. The list of infecting organism and susceptible antibiotics were given in the table I. The diagnosis of deep infection was made in a mean period of 5.5 weeks (range, 2-10 weeks) after the index management of the fractures. During the diagnosis of deep infection, no patient had clinical or radiological sign of fracture union.

**Surgical technique**

The wound was opened. Deep wound cultures were obtained. Then NCP procedures were performed, respectively. In the patients who had undergone the plate-screw system or external fixator, all implants were removed. The infected and necrotic soft tissues and bone fragments were debrided. Copious irrigation was performed. In the patients who had undergone osteosynthesis with IM nailing, the IM nail removed. Intramedullary reaming was performed along with copious irrigation. Rifampisins (Rif amp, Koçak Farma, Istanbul, Türkiye) was used in saline solution during irrigation.

After debridment and irrigation a 4.5 mm locking compression plate (LCP, TST San. Ltd. Şti, Istanbul, Turkey) was used for fracture fixation. After reduction was obtained the plate was inserted. The proximal and distal screws were inserted. During locking the screw head to the plate care was taken to avoid contact between the plate and the bone cortices. Once the fixation was achieved, the alignment was checked by the fluoroscopy. The authors attempted to provide fixation at least with 3 screws (6 cortex) on both sides of the fracture line. Wound closed as usual.

Once sample collected, all patients were administered first-generation cephalosporin perioperatively. Following the identification of the causative organism and its antibiotic susceptibility, the patients were switched to the appropriate parenteral antibiotic treatment. The length of antibiotic period was determined according to the clinical and laboratory parameters.

**RESULTS**

The infecting organism was methicillin-resistant staphylococcus aureus (MRSA) in 3, methicillin-sensitive staphylococcus aureus (MSSA) in 5, pseudomonas auroginosa in 2, and enterobacteriacea in 2 patients (Table I). Antibiotic therapy was continued for 3 weeks in 10 patients and 6 weeks in 4 patients. Union achieved in all patients (Fig. 1). The mean follow-up time was 25.7 months (range, 15-45 months). Mean time to union was 17 weeks (range, 11-38 weeks). Delayed union observed in 3 patients. The causes of delayed union were implant failure, screw loosening, and persistent infection (Table I). Implants were changed in these patients. Infection was treated without additional surgery or debridement in 2 patients. One patient developed persistent and the chronic osteomyelitis. This patient underwent debridement and irrigation for 5 times. Although union was achieved in this patient, on the postoperative 38th week, the infection still recurs intermittently.

**DISCUSSION**

In this study we used NCP method in the treatment of deep infection encountered after index.

Acta Orthopædica Belgica, Vol. 81 - 3 - 2015
surgery of tibia and femur fractures. Union achieved in all patients. Three patients had delayed union and one patient had osteomyelitis. These results showed that NCP technique is a successful and reliable method for infected fractures of tibia and femur.

Infection is still a serious complication in orthopaedic surgery. If a fracture accompanied with the infection the clinical scenario becomes more complex. The treatment of infectious fractures is further complicated by two conditions: deep infection and fracture. There is a debate about the management of infectious fractures. It is suggested infection is spontaneously resolved following the complete union, thus the primary aim of the treatment should be to achieve the radiological union. Therefore the implant should not be removed (12,22). Accordingly, the standardized treatment protocol suggested for the cases with a stable fixation includes irrigation and debridement along with long-term antibiotic therapy (14,18,20). However, the success rates using this protocol was reported between 60% and 70% (6).

Table I. — All patient data

<table>
<thead>
<tr>
<th>Case</th>
<th>Age/sex</th>
<th>Injury mechanism</th>
<th>OTA</th>
<th>Gustilo-Anderon</th>
<th>Fracture location</th>
<th>Previous implant</th>
<th>Suspectable microorganism</th>
<th>Union time (Wk)</th>
<th>Follow-up (mo)</th>
<th>Complications</th>
<th>No. Of operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>43/M</td>
<td>occupational accident</td>
<td>OTA-A</td>
<td>-</td>
<td>Femur proximal</td>
<td>Plate</td>
<td>MSSA</td>
<td>10</td>
<td>15</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>51/M</td>
<td>traffic accident</td>
<td>OTA-B</td>
<td>-</td>
<td>Femur proximal</td>
<td>IM nail</td>
<td>–</td>
<td>15</td>
<td>26</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>35/F</td>
<td>shotgun injury</td>
<td>OTA-C</td>
<td>IIIB</td>
<td>Femur distal</td>
<td>IM nail</td>
<td>enterobacteriacea</td>
<td>28</td>
<td>32</td>
<td>implant failure</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>34/M</td>
<td>traffic accident</td>
<td>OTA-A</td>
<td>-</td>
<td>Femur distal</td>
<td>Plate</td>
<td>–</td>
<td>13</td>
<td>17</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>42/M</td>
<td>shotgun injury</td>
<td>OTA-B</td>
<td>IIIB</td>
<td>Femur distal</td>
<td>IM nail</td>
<td>MSSA</td>
<td>16</td>
<td>26</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>23/M</td>
<td>shotgun injury</td>
<td>OTA-C</td>
<td>IIIA</td>
<td>Femur distal</td>
<td>IM nail</td>
<td>MRSA</td>
<td>16</td>
<td>22</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>31/F</td>
<td>traffic accident</td>
<td>OTA-B</td>
<td>II</td>
<td>Tibia diaphysis</td>
<td>Plate</td>
<td>MSSA</td>
<td>11</td>
<td>34</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>45/M</td>
<td>traffic accident</td>
<td>OTA-B</td>
<td>IIIA</td>
<td>Tibia diaphysis</td>
<td>EF</td>
<td>MSSA</td>
<td>13</td>
<td>35</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>21/F</td>
<td>traffic accident</td>
<td>OTA-B</td>
<td>II</td>
<td>Tibia diaphysis</td>
<td>EF</td>
<td>enterobacteriacea</td>
<td>14</td>
<td>24</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>26/M</td>
<td>traffic accident</td>
<td>OTA-A</td>
<td>II</td>
<td>Tibia diaphysis</td>
<td>IM nail</td>
<td>–</td>
<td>15</td>
<td>27</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>38/M</td>
<td>Fall</td>
<td>OTA-C</td>
<td>IIIIC</td>
<td>Tibia diaphysis</td>
<td>EF</td>
<td>pseudomonas auroginosa</td>
<td>38</td>
<td>45</td>
<td>chronic osteomyelitis</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>27/M</td>
<td>traffic accident</td>
<td>OTA-B</td>
<td>-</td>
<td>Tibia diaphysis</td>
<td>IM nail</td>
<td>MSSA</td>
<td>13</td>
<td>19</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>64/M</td>
<td>traffic accident</td>
<td>OTA-C</td>
<td>IIIA</td>
<td>Tibia distal</td>
<td>IM nail</td>
<td>MRSA</td>
<td>31</td>
<td>34</td>
<td>implant failure</td>
<td>3</td>
</tr>
<tr>
<td>14</td>
<td>38/M</td>
<td>Fall</td>
<td>OTA-B</td>
<td>I</td>
<td>Tibia distal</td>
<td>Plate</td>
<td>pseudomonas auroginosa</td>
<td>12</td>
<td>15</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>32/F</td>
<td>traffic accident</td>
<td>OTA-B</td>
<td>I</td>
<td>Tibia distal</td>
<td>IM nail</td>
<td>MRSA</td>
<td>11</td>
<td>19</td>
<td>–</td>
<td>2</td>
</tr>
</tbody>
</table>

Abbreviations : EF, External fixator ; IM, Intramedullary.
Fig. 1. — A 45-year-old male patient with infectious open tibial fracture due to traffic accident: a) During initial surgery; b) Implementation of external fixator and wound coverage, c, d) Anteroposterior (AP) and lateral radiograph following external fixation, e, f) postoperative AP and lateral radiographs following NCP, g, h) AP and lateral radiograph at 35 month follow-up showed excellent union.
On the other hand, this protocol is difficult to perform in the patients presenting with infections and internal fixation at the same time. This difficulty was attributed to protective biofilm that produced by infecting microorganisms on the implant surface (4). Hence, the microorganisms are protected from defensive cells and antibiotics (15). Throughout the antibiotic therapy, the microorganisms remain in the rest stage and stop their bacterial activities. In this period, the fracture may achieve complete union. However, Rightmire et al (21) claimed that debridement and retaining the implant may not be as effective as expected and that the infection recurred (16%) even after the implant is removed following the union. Berkes et al (3) also claim that the intramedullary nails that are used as fixation materials, especially in open fractures, have a high rate of infection which leads to lower success rates; therefore, the implant should be removed in the infectious fractures even if stabilization is achieved.

Ovasaka et al (17) reported 67% success using debridement and implant retaining after series of infected ankle surgery. They stated that debridement and implant removal was successful. Similarly, Zalavras et al (24) reported union in all patient (n = 4) using debridement and implant retaining, however in 75% (n = 3) of patients the infection was recurred and they have to remove the implants. Al-Mayahi et al (1) treated 20 patient using the same method. They reported 85% (n = 17) successful results.

The success rates in our study (93%) was higher when compared to the previous studies using debridement and implant retaining. We consider that a successful therapy in the management of infectious fractures means eradicating the infection as well as achieving fracture union. For this reason, we consider that both of these problems could be treated with the NCP method.

The pattern, the size, the surface, and the biocompatibility of the implants are key factors for the colonization and biofilm processes of bacteria (2,12,16). In addition, the amount of the contact surface between the implant and bone is also effective on the formation of biofilm since the size of this surface is correlated with the formation of infection and bacterial resistance (23). Both IM nailing and conventional plate-screw systems have the large implant-bone contact surface. Therefore, using these materials

---

*Fig. 2. — A 43-year-old male sustained proximal femoral fragment following occupational accident; a) Anteroposterior (AP) radiograph following initial procedure, b) AP graph following second procedure, c) Postoperative AP graph following internal splint, d) AP graph at 15 month following internal splint.*
may further complicate the treatment of infection (5). The success of the treatment in the infectious fractures is mainly dependent on choosing an ideal implant that would do minimal damage to the bone and soft tissues. Also a minimally invasive procedure should be preferred to preserve the periosteal circulation as much as possible. In our procedure, the contact between the plate and the bone is eliminated. High union rate (100%) in the present study suggests that this procedure might protect the periosteal vascular system. Theoretically, this novel procedure has two advantages. First, the NCP system works as in external fixator that necessary for the treatment of deep infection without disadvantageous external fixation (ie, pin tract infection, joint stiffness). Second, NCP provide adequate and reliable internal fixation which is required for fracture stabilization (Fig. 2).

This study has several limitations. First, it is retrospective and comprises a relatively small number of patients. Second, the study group consists of both tibia and femur fractures. Third, the implant that used in the index surgery (external fixator, IM nail, and plates) was not homogeneous. Lastly, the infecting microorganisms were not homogenous. Further studies consisting homogeneous subtype of fracture and infecting microorganism with high number patients may reveal better results for the indications and effectiveness of NCP method. Also, researchers may investigate the biofilm formation using the NCP system. Furthermore, the role of NCP method in preventing the infection caused by resistant microorganisms may be evaluated.

To summarize, NCP method has both an advantageous of stable internal fixation with no contact between the implant and the bone tissues. This study showed that NCP technique is highly effective and reliable alternative method in the treatment of infected tibia or femur fractures.

REFERENCES

17. Perren SM. Evolution of the internal fixation of long bone fractures. The scientific basis of biological internal fixation :


