Original article

Treatment of postoperative tibial chronic osteomyelitis using bone transport techniques; an observational study

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Abstract

Purpose: Postoperative Tibial chronic osteomyelitis is one of the most challenging orthopaedic conditions especially when extensive, the anatomy of subcutaneous anteromedial part of the tibia with less soft tissue coverage complicates the situation. The extent of infected tibial part varies in size and duration from one patient to another. We report our experience using Bifocal and Monofocal bone transport techniques with regard to clinical outcome, recurrence of infection and re-fracture rate.

Methods: This is a retrospective observational review of 49 patients with postoperative Tibial chronic osteomyelitis which were treated using either Bifocal distraction compression BFDCO technique group I (31 patients) or Monofocal compression osteosynthesis MFCO technique Group II (18 patients). The average age of the patients was (41.6 ± 13.1 years), (range: 17–67 years). Leg length discrepancy was measured in 33 (58.9%) patients with an average of (1.4 ± 1.7 cm). Contracture of the ankle joint and equinus deformity were detected in 36 (64.3%) patients. Pre and Post-operative radiography together with Modified Irzhansky A.A et al. leg functional assessment system were used to assess the functional outcome.

Results: The time spent in the Ilizarov fixator (External Fixation Index) in the first group was (142 ± 72 days) and in the second group was (75 ± 54 days). The infection recurred in 2 patients (6%) in group I and in 5 patients (28%) in group II. Lack of consolidation or re-fracture within 6 months after the dismantling of the apparatus was detected in 6 patients (19.5%) in group I and in 5 patients (27.8%) in group II. Lack of consolidation or re-fracture within 6 months after dismantling of the apparatus in group I was detected in 6 patients (19.5%) in group I and in 5 patients (27.8%) in Group II. The average functional state score (AFSS) in the first group was (12.45 ± 2.41) on admission and increased to (16.16 ± 2.99) on the final follow-up which corresponded to a “good” result. In the second group II the AFSS was (12.11 ± 2.22) on admission and increased to (15.06 ± 2.88) at the final follow-up which corresponded to a “satisfactory" result.

Conclusion: Treatment of Tibial chronic osteomyelitis using either Bifocal or Monofocal bone transport is an effective method. However our results have demonstrated better functional outcome and less infection recurrence and re-fracture rates when using the Bifocal distraction compression technique (BFDCO).

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1. Introduction

Chronic osteomyelitis of the tibia is one of the most serious complications after intra or extramedullary osteosynthesis of leg fractures which occurs in (15–41.2%) of all extremity fractures. It represents physical, socioeconomic and psychological impact on patients. It is estimated that half of the osteomyelitis cases in adults are due to trauma. Moreover, a multicenteric study have shown that people of the working age 20–50 years old are the most often affected which represent a major impact on patients quality of life and also a financial burden to both individuals and health care systems. Established osteomyelitis present a challenging complication to the treating surgeon which could reach up to

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were detected in 36 (64.3%) patients. Contracture of the ankle joint and equinus deformity were detected in 36 (64.3%) patients. Tibial fracture consolidation was achieved in only 4 patients (8.1%). A recent increase of the condition is reported due to different reasons which includes using inappropriate metal work, contaminated surgical environment, open fractures, foreign bodies and hematogenous spread. The condition is usually recalcitrant to conventional methods like Sequestrectomy plus antibiotics as the only strategy of treatment especially when the infection is extensive and long standing. Ilizarov technique is a well-known technique for bone transport. To date, the Ilizarov method remains an alternative method for complex treatment of this category of patients, providing suppression of the infection process and reconstruction of the affected part whether bony defects, shortening or deformity. Moreover, limb salvage and reconstruction allows for a predictable and most effective way for treating complex chronic osteomyelitis. In this study we have studied and analyzed the results of using bifocal distraction-compression osteosynthesis (BFDCO) technique and the Monofocal compression osteosynthesis (MFCO) technique for treatment of this condition.

### 2. Materials and methods

This is a retrospective observational review of 49 patients with postoperative Tibial chronic osteomyelitis in the period from 2005 to 2014 which were treated using either Bifocal distraction compression BFDCO technique group I (31 patients) or Monofocal compression osteosynthesis MFCO technique Group II (18 patients). The average age of the patients was (41.6 ± 13.1 years), (range: 17–67 years). Leg length discrepancy was measured in 33 (58.9%) patients with an average of (1.4 ± 1.7 cm). Contracture of the ankle joint and equinus deformity were detected in 36 (64.3%) patients. Pre and Post-operative radiography together with Modified Irzhansky A.A et al. leg functional assessment system were used to assess the functional outcome. The study was approved by our Institutional Review Board (IRB). Men constituted 70% of the cases. The majority of patients had a high-energy injury during an accident, fall from a height or at work. There were 26 closed and 23 open fractures. Prior to admission to our center, all patients had metal work fixation of their fractures with plates, nails, screws and external fixators including Ilizarov Ring fixators. In the early post-operative period, 26 (53%) patients (11 of them had a closed fracture) developed local purulent discharge from the fracture site. Upon admission, patients complained of pain during exertion on the injured limb, active wounds and fistulas with purulent discharge, and in some cases, increased body temperature, general weakness and malaise. Local examination of all patients showed wound defects with exposed parts of bone at the bottom (12 cases 24.5%) and/or fistulous passages (37 cases 75.5%) with purulent discharge. In 34 cases (69.4%) the skin of the lower leg in the infected area was represented by scar tissue fused to the underlying bone. In 40 (81.6%) patients leg and foot edema was present and in 8 cases (16.3%) post-thrombotic syndrome was detected. Leg length discrepancy was revealed in 33 (58.9%) patients on average of (1.4 ± 1.7 cm). Non-union was observed clinically in 45 (91.8%) patients. Tibial fracture consolidation was achieved in only 4 patients (8.1%). Contracture of the ankle joint and equinus deformity were detected in 36 (64.3%) patients.

Radiography in all patients was characterized by destruction of the tibia, the presence in some cases of foreign bodies and bony defects of the tibia ranging from 1 to 10 cm (averaged 2.3 ± 1.8 cm) with regard to fixation modality two patients arrived with an intramedullary nail, 13 patients with a bone plate, three patients had fragments of screws in the tibia and 6 patients had Ilizarov apparatus. The results of the microbial swab for culture and sensitivity was represented by gram-positive flora (St. Aureus). The gram-negative flora was represented by pseudomonas aeruginosa and Corynebacterium spp. Microbial associations were detected in 59% of patients with closed fracture and in 29% of patients with an open fracture. Statistical analysis used categorical variables presented as number and percentage and continuous variables were presented as mean ± standard deviation (SD). The data were analyzed using Microsoft Excel office 2013.

### 3. Surgical technique

The treatment of patients is carried out at the infection department which is represented by a separate building. The protocol consisted of debridement and fixation by Ilizarov apparatus, with regard to the technique we either used the bifocal distraction-compression osteosynthesis (BFDCO) technique or the monofocal compression osteosynthesis (MFCO) technique depending on the size of the bone defect the patients were divided into two groups: group I consisted of (31 patients) treated by the BFDCO technique with resultant defects ≥2 cm and Group II (18 patients) treated by the Monofocal compression osteosynthesis MFCO technique with resultant defects ≤2 cm. Intra-operative swabs are taken from the discharge fluid, superficial and deep tissues and bone, we review x-rays, CT scans and when there is sinus we inject a brilliant green dye to determine the extent of the infection (Fig. 1). Skin and soft tissue incisions are made layer by layer to access bone segments, removal of infected tissues is done until healthy bleeding margins could be noticed on the osseous bed (paprika sign) when sequestrectomy is performed the wound is washed thoroughly with antiseptic solution and with ultra-sonic wash system, a drain is inserted inside the wound and with skin undermining a primary closure of the wound is done (Fig. 1). Corticotomy is performed when there is a need to compensate for bony defects with the BFDCO technique, when the bone transport is about to complete 2–3 mm before docking we open the wound and perform debridement of the remaining non-viable and fibrous tissue associated with process of bone transport, we also perform refreshment of the bony ends and close the wound surgically and instruct the patient to continue the distraction 1–5 mm beyond docking to make sure that bone ends are engaged and in some cases when the proximal tibia provide a tapering end we continue distraction until it descend inside the distal fragment (Fig. 1).

### 4. Results

Assessment of the results of treatment in patients with post-traumatic tibial osteomyelitis was carried out within two years after treatment according to the main clinical criteria: suppression of the pyogenic infection, achievement of consolidation of bone fragments and the functional state of the limb. The time spent in Ilizarov fixator in patients in the first group was (142 ± 72 days) and in the second group was (75 ± 54 days) since the first group have larger defects. The results for both groups have shown consolidation of bone fragments in (81.5%) of patients in the first group and (72.2%) in the second group. Infection recurrence was observed in 14.3%, and complete fusion was achieved in 81.5% and hence Lack of consolidation or re-fracture within 6 months after dismantling of the apparatus was detected in 6 (19.5%) patients in group I and in 5 patients (27.8%) in group II. In addition 2 (6%) patients developed recurrence of infection in group I and in 5 (28%) patients in group II. We used the validation and cross-cultural adaptation of rating systems WOMAC and FJ-12 for evaluating the functional results of treatment. To simplify the use of the scale we identified four main criteria: the presence of pain, impaired function of the ankle joint, shortening of the limb and the use of additional means of support. Each of these criteria included 5 parameters characterizing the degree of the functional state of the limb. The maximum score was...

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*N.M. Klushin, S.I. Burnashov, W.A. Mekki et al. Journal of Clinical Orthopaedics and Trauma 24 (2022) 101652*
Fig. 1. 39 years Male with Chronic post-traumatic osteomyelitis of the right tibia, treatment of the patient according to the BFDKO technique (A) infected plate fixation of the Right Tibia, (B) skin ulceration over the plate with discharging sinus, (C) Plate removal but with infected nonunion and unstable leg, (D) brilliant green dye to determine the extent of the infection, (E) Resection of 10 cm of sequestrum, (F,G) Proximal Tibial osteotomy and start of bone transport, (H) Clinical appearance after one year follow up with healed ulceration and sinuses with good function at both knee and Ankle joints (20 points), (I) Radiographic appearance one year postoperative showing consolidated regenerate and healed docking site.
20 points (Table 1). Excellent = 19–20 points, good = 16–18, satisfactory = 13–15 and less than 13 is unsatisfactory. The calculation of the average functional state score (AFSS) made it possible to study the results of treatment in each group.

In all 49 patients the preoperative score of the AFSS was (12.33 ± 2.32) and at final follow-up increased to (15.75 ± 2.97) which corresponded to an overall good result.

In the first group I the preoperative AFSS score was (12.45 ± 2.41) and increased to (16.16 ± 2.99) at final follow-up which corresponded to good result. In the second group II the preoperative AFSS score was (12.11 ± 2.22) and increased to (15.06 ± 2.88) which corresponded to satisfactory result.

5. Discussion

Postoperative chronic osteomyelitis provides a difficult and challenging condition for the treating surgeon, the traditional methods consist of removal of dead bone and tissues or sequestrectomy and administering oral or IV antibiotics and repeated fixation by metalwork or linear external fixators which proved to be futile and ineffective in the majority of cases14,15 fixation by metalwork usually result in recurrence of infection and reappearance of the sinuses, with this regard it is very important to establish an extra focal fixation in the healthy part to avoid any further dissemination of infection, another element which is mostly needed is the stability of the fixation which is provided by Ilizarov fixators.16,17 Moreover the use of tension and compression forces create regenerative environment and increased bactericidal activity by increasing angiogenic reparative activities.18,19 That’s why Ilizarov believed that infection burns in the flame of regeneration, in this aspect, the BFDCO has an advantage over the MFCO by having osteotomy and distraction histogenesis to transport bone fragment to the docking site and creating new tissues, our results showed that the number of infection relapse in group I was detected in 2 patients (6%) which is less than group II which was detected in 5 patients (28%). Lack of consolidation or re-fracture within 6 months after the dismantling of the apparatus in group I was detected in 2 patients (19.5%), in group II in 5 patients (27.8%) similar results were obtained by McNally M et al.17 which reported 79 cases of infected tibial nonunion which were treated by Ilizarov technique, they found that consolidation of bone fragments was achieved in 81% of patients in the first group, and 72% in the second group. Purulent infection recurrence was observed in 14.3%, and complete fusion was achieved in 77.5%, they concluded that Monofocal compression achieved the lowest union rate (73.7%) and a re-fracture rate of (31.6%) where in the bifocal distraction compression group union was achieved 100% after further treatment which is a merit accredited to the use of Ilizarov technique.21 Other similar results were obtained by different authors20–22. The use of distraction histogenesis was also effective in treating septic coxitis.26 We opt to the Monofocal compression technique in cases with small defects ≤2 cm and with shorter duration of infection, most of infection recurrence and re-fracture were in this group. In cases with larger defects ≥2.5 cm, Intercahyre resection of the necrotic bone is performed to eradicate the infection and bifocal compression distraction technique BFDCO is carried out to compensate for the defect.20–22 In our series, infection was eradicated in most cases with the distraction compression technique, but this may be due to the meticulous debridement of the infected tissue with a larger resection gap compared with the Monofocal compression group. The BFDCO has the advantage of concomitant accurate correction of deformity, leg length correction and bony union with poor soft tissue conditions. Magadum et al.23 presented 27 cases treated with bifocal compression distraction. They performed acute shortening with no reported complications in defects averaging 10 cm, with the largest defect measuring 17 cm. In our cases, we could not acutely compress such large defects, because of scarred and irritated soft tissues. In cases in which the overall limb alignment was satisfactory with an intact fibula, we prefer to retain the intact fibula for stability and continue with the bone transport. One of the main advantages of the Ilizarov technique is that it allows for early weight bearing in comparison to other techniques like the Masquelet technique which does not allow for early weight bearing. Karger et al.27 Our patients are mostly able to weight bear at the first postoperative day which may prevent other complications as osteoporosis, muscle atrophy and gait disturbances associated with other techniques.17–25

6. Conclusion

Treatment of Tibial chronic osteomyelitis using either Bifocal or Monofocal bone transport is an effective method. However our results have demonstrated better functional outcome and less infection recurrence and re-fracture rates when using the Bifocal distraction compression technique (BFDCO).

7. Summary and highlights

1. Postoperative Tibial chronic osteomyelitis is on rise.
2. Meticulous debridement, IV Antibiotics according to C/S and ring external fixators (Ilizarov) to guard against axial deviation is an effective strategy for treatment.
3. For small defects ≤2 cm the Monofocal Compression osteosynthesis technique (MFCO) is the preferred and more effective method.
4. For larger defects ≥2 cm the Bifocal distraction Compression osteosynthesis bone transport technique (BFDCO) is the preferred and more effective method.
5. In our series Bifocal distraction Compression osteosynthesis bone transport technique (BFDCO) has reported less infection recurrence and re-fracture rate than the Monofocal Compression osteosynthesis technique (MFCO).
6. In general, surgeons are advised to us the Bifocal distraction Compression osteosynthesis bone transport technique (BFDCO)

Table 1

<table>
<thead>
<tr>
<th>Grade</th>
<th>Assessment Indicators</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Pain</td>
</tr>
<tr>
<td>1 point</td>
<td>Standing alone</td>
</tr>
<tr>
<td>2 points</td>
<td>Intermittent at rest</td>
</tr>
<tr>
<td>3 points</td>
<td>Constant walking</td>
</tr>
<tr>
<td>4 points</td>
<td>Intermittent walking</td>
</tr>
<tr>
<td>5 points</td>
<td>No pain</td>
</tr>
</tbody>
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ROM: Range of Motion.
in patients with larger bony defects and more complicated cases where deformity correction and lengthening might be required.

Ethical approval

The procedures performed in this study were in accordance with our institutional standards and approved by the Ethical Committee of our Center. The study was carried out as per the 1964 Helsinki declaration and its later amendments or comparable ethical standards https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4763146/

Informed consent

Informed consent was obtained from all individual participants included in the study.

Declaration of competing interest

All Authors declare that they have no conflict of Interest with regard to the study.

References