Comparison of Bone Preserving and Radical Surgical Treatment in 32 Cases of Calcaneal Osteomyelitis

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Abstract

Introduction. Radical procedures like calcanectomy and amputation performed for calcaneal osteomyelitis are regarded as effective in eradication of infection even though potentially functionally disabling. Bone sparing procedures offer better functional result at the expense of potentially worse infection control. The aim of the study has been to assess the influence of the surgical radicalism as much as the extent of bone infection on the final outcome in the surgical therapy of chronic calcaneal osteomyelitis (CO). Material and method. 32 patients with chronic CO have comprised the group under study: 8 with superficial type, 12 localised type and 12 with diffuse type according to Cierny-Mader classification. The aim of the treatment was to heal infection, preserve the heel shape and achieve good skin coverage over the calcaneus. The therapy consisted of 9 debridement surgeries with or without flaps, 8 drilling-operations of the calcaneus with application of collagen-gentamicin-sponge in bore holes, 15 partial and 2 total calcanectomies, and 4 below-the knee amputations. Results. The healing of infection and wound has been achieved after 7 of 9 debridements, 6 of 8 drilling-operations, 13 of 15 partial and all total calcanectomies. Conclusion. Bone preserving operations in chronic calcaneal osteomyelitis provided inferior infection control (76.47% vs 88.24%) and worse patient satisfaction (88.24% vs 100%) and almost comparable ambulation (100% vs 93.33%). Drilling of the calcaneus with application of collagen sponge containing gentamicin performed in chronic diffuse calcaneal osteomyelitis seems to offer a viable alternative to partial or radical calcanectomy. Level of evidence: V.

Key words: chronic calcaneal osteomyelitis; calcanectomy, collagen-gentamicin sponge; local antibiotic application.

Introduction

Chronic calcaneal osteomyelitis (CO) is a rare form of bacterial osteomyelitis [1]. It develops either as sequelae of penetrating wound located over the calcaneus, especially in diabetic patients with vascular compromise, or as hematogenous bone infection [2, 3, 4]. Up to 60% of the open calcaneal fractures, especially with intra-articular involvement, is accompanied by infection [5]. Optimal therapy for chronic CO should combine eradication of infection, preservation of the bone stock and attachment of the Achilles tendon as well as retaining of ambulation [6, 7]. There are various ways of surgical therapy of CO. Standard treatment for CO usually includes partial or total calcanectomy and below-the knee amputation. In the extensive inflammatory involvement of spongiotic substance of the calcaneus it is difficult, however, to distinguish which part of bone could be defined as sequestrum [8]. Thus, the classical sequestrectomy with preservation of viable surrounding tissues is not possible. Most of the published case studies of CO present the experience with calcanectomy or soft tissue transfer. The mode of treatment depends on whether the team is an orthopedic or plastic surgical team. From the functional point of view the therapy for CO should rather be bone sparing than radical. Bone sparing procedures - regarded as alternative for calcanectomy seem to be functionally more satisfactory, but provide worse infection control.
mine the extent of inflammatory process and the sur-
gery planning, Cierny-Mader (CM) classification has
been proposed [8]. The classification distinguishes
medullary (CM I), superficial (CM II), localized (CM
III), and diffuse (CM IV) involvement of the bone.
Superficial type of CO is diagnosed when inflam-
matory changes on X-ray (sclerotic or osteolyt-
ic) or on MRI scans (abnormal signal with contrast
enhancement) involve strictly localized region, or less
than 50% of the volume of the calcaneus [10, 11].
Changes with the extension within the calcaneus
greater than 50% are classified as diffuse CO.

The aim of this study has been to compare the
clinical and functional treatment results in 32 consec-
tutive cases treated for chronic CO either by bone
preserving protocol or by partial or total calcane-
tomy as well as to evaluate the influence of the extent
of the infection in the bone and of the performed opera-
tion on the final outcome.

Patients and methods

The retrospective study includes 32 consecutive
patients treated due to chronic bacterial osteomyelitis
of the calcaneus from 1993 to 2010. The follow up
ranges from 3 to 15 years (average 4,5 years). The
study included 14 women and 18 men, aging from
17 to 78 years of age (average 42 years). All patients had
suffered from exogenic CO and were treated at the
orthopedic department, and whenever necessary in
cooperation with a plastic surgeon. The microorgan-
isms cultured from bone specimens have been: Staphylococcus aureus (13 cases), Staphylococcus epidermidis (5 cases), Pseudomonas aeruginosa (4
cases), Proteus mirabilis (3 cases), Enterococcus fae-
calis (2 cases), and Propionibacterium spp. (1 case).
Negative biopsies have been obtained in 4 cases.

The following types of calcaneal osteomyelitis have
been treated according to Cierny-Mader classification: 8 cases of type II, 12 cases of type III, and 12
cases of type IV. Patients with CO have been classified
according to Cierny and Mader (CM) host classifica-
tion: 14 cases were class A, 13 class Bl and 5 class Bs.
In 14 cases CM class A, CO developed as sequela of
pressure ulcer (3), due to puncture wound (6), due to
traumatic wound over calcaneus (2) and in 3 cases of
calcaneal fractures managed with pin fixation. Local
compromising factors in 13 cases class Bl included
neurological problems: sciatic or tibial nerve injury
(5), other peripheral neuropathy (4), spinal cord injury
(4). Compromising factors in class Bs cases included:
diabetes (4) and chronic renal insufficiency (1). 28
from 32 patients have been ambulatory prior to the
treatment and 4 cases with spinal cord injury have
been non-ambulatory. Characteristics of treated cases
and performed operations is shown in table 1.

The treatment aimed to preserve the bone stock
and the shape of the calcaneus as well as to achieve
good skin coverage. The author’s own bone preserv-
ing technique for chronic diffuse CO has been de-
veloped with the expectation to preserve the cancellous
bone of the calcaneus, deliver the antibiotic to the
bone and maintain the function of the foot. The cal-
caneus is approached either through the existing skin
defect, through the split heel approach (fig. 1a) or
through the lateral incision [9]. After the exposure of
the calcaneus and debridement of potentially infected
tissue covering the bone, 6 to 9 holes are drilled in
the cancellous bone of the calcaneus, each 4 mm in diam-
eter (fig. 1b). As the next step the “peg”s” formed from
one piece of collagen-gentamicin sponge (CGS) con-
taining 130 mg of gentamicin sulphate are introduced
into drill holes (fig. 1c). According to the authors’ ex-
perience 6 to 9 drill holes does not weaken the me-
chanical strength of the calcaneus (fig. 1d).

Locally introduced CGS enables the antibiotic to
diffuse into cancellous bone, resulting in eradica-
tion of infection and maintenance of important part of
the calcaneus. When the skin defect over the calcaneus is
present, local skin flap for coverage of the bone is
performed at the same stage. Application of CGS to
the drill holes has been based on the sensitivity of
infecting bacteria to high concentrations of gentami-
cin.

In cases of known preoperative bacterial sensi-
tivity (cultures from bone exposed within the wound)
as well as cases without preoperative calcaneus ex-
position – the application of CGS has been the form of
prophylactic and preemptive antimicrobial therapy of
bone infection. Postoperative antimicrobial therapy
has been based on biopsies taken intraoperatively
from the bone. The protocol included intravenous or
oral antibiotics – initially empiric (in cases with un-
known etiological factor) and having obtained results
from tissue cultures - culture specific antibiotics for 4
weeks. Cases treated with drilling and application of
CGS received postoperative suppressive antibiotic
therapy for 2 weeks.

The type of the surgical treatment has been tai-
lored to the extension of inflammation determined by
X-ray or MRI, according to CM classification (table 1).
Debridement, with or without local flap, has been
performed in 9 cases: in 8 cases with type II and in one
case type III of CO (4 cases: without flap; 5 cases of
type II CO and with pressure ulcer: combined with
local flap). Debridements without flap have been per-
formed through the split-heel approach and in cases
with pressure ulcers – through the skin defect.
In one case two debridements have been performed.

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Table 1. Characteristics of 32 patients and 41 operations performed for calcaneal osteomyelitis. Table legend: *staged or repetitive surgery; Operations: OP1 - Drilling + Collagen Gentamicin Sponge; OP2 - Debridement; 2a - Debridement + fasciocutaneous flap; 2b - Debridement + cross-leg fascio-cutaneous flap; OP3 - Partial calcanectomy; 3a - Partial calcanectomy + Antibiotic Loaded Acrylic Cement Spacer; OP4 - Calcanectomy; OP5 - Below-the-knee amputation.

<table>
<thead>
<tr>
<th>Pat No</th>
<th>Sex/age</th>
<th>CM type</th>
<th>Risk factor for calcaneal osteomyelitis</th>
<th>OP1</th>
<th>OP2</th>
<th>OP3</th>
<th>OP4</th>
<th>OP5</th>
<th>Healing of infection</th>
<th>Walking ability</th>
<th>Satisfaction with treatment</th>
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<td>+</td>
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<tr>
<td>2</td>
<td>F36</td>
<td>IIA</td>
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<td>+</td>
<td>+</td>
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<tr>
<td>5</td>
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<td>2a</td>
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<td>IIBL</td>
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<td>+</td>
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<td>+</td>
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<td>+</td>
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<td>IVBs</td>
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<tr>
<td>25</td>
<td>F48</td>
<td>IVA</td>
<td>Traumatic wound with exposition of the calcaneus</td>
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<td>+</td>
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<td>F17</td>
<td>IVBL</td>
<td>Pressure ulcer over heel, spinal cord injury</td>
<td>1</td>
<td>+</td>
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<tr>
<td>28</td>
<td>M33</td>
<td>IVBL</td>
<td>Pressure ulcer over heel, spinal cord injury</td>
<td>1</td>
<td>+</td>
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<td>29*</td>
<td>M78</td>
<td>IVBs</td>
<td>Calcaneal fracture managed with pins, diabetes</td>
<td>3a</td>
<td>+</td>
<td>+</td>
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<td>Calcaneal fracture managed with pins</td>
<td>3a</td>
<td>+</td>
<td>+</td>
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<td>F71</td>
<td>IVBs</td>
<td>Calcaneal fracture managed with pins, renal failure</td>
<td>3a</td>
<td>+</td>
<td>+</td>
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<td>3</td>
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</table>
In two cases treated initially by debridement, partial calcanectomy has been performed because of flap failure. Drilling of the calcaneus and application of CGS in bore holes has been performed in 8 cases with type IV of CO. The treatment has failed in 2 cases and consequently resulted in below-the-knee amputation. Partial calcanectomy has been performed in 17 cases: as primary treatment in 11 “localized cases” and as secondary salvage procedure in 2 cases after failed debridement with local flap. Partial calcanectomy has also been attempted in 4 “diffuse” cases with cavitory defect of the bone, with cavity volume larger than 2-3 cm³. In 3 from 4 mentioned cases hand-made acrylic cement spacer, containing low-dose of gentamicin (less than 1,0 g of antibiotic within 40 g of cement) has been introduced into the defect. The treatment has failed and total calcanectomy has eventually been performed in 1 case and below-the-knee amputation in 2 other cases with diffuse CO. Total calcanectomy has been performed as a final treatment in 2 cases. Below-the knee amputation has been performed as final procedure after failed drilling operations (2 cases) and after failed partial calcanectomies with cement spacer (2 cases).

The final results of therapy have been assessed based on wound and bone infection healing, maintenance of walking ability and subjective assessment performed by the patient. Infection control has been assessed based on clinical examination, inflammatory markers (ESR, CRP, WBC) and radiological signs of healing. The radiological signs of homogenous remodeling, resorption or sclerosis of the calcaneus have been analysed on standard lateral and axial X-ray of the calcaneus. Functional assessment has included walking ability and the use of orthopedic devices. In subjective assessment patients have expressed satisfaction with treatment results. The study was performed following the Declaration of Helsinki principles and informed consent has been obtained from each patient prior to inclusion to the study. The study has been approved by the responsible authorities of Medical University of Warsaw.

Results
Finally the results of 37 operations have been assessed: 10 debridments, 8 drilling procedures, 17 partial and 2 total calcanectomies. Complete wound healing and the absence of bone infection for at least 2 years (minimal follow-up) has been obtained in 30 of 32 cases (93,75%). Debridement has been effective in 7 of 10 operations, drilling procedure in 6 of 8, partial calcanectomy in 13 of 17, and total calcanectomy in 2 of 2 cases (table 1). In 4 cases with diffuse CO partial calcanectomy has been
ineffective and finally a total calcanectomy has been performed in 2 cases and in 2 other cases a below-the-knee amputation. Acrylic cement spacer containing low-dose gentamicin have turned out to be ineffective. In total, the bone preserving operations (debridments or drilling with application of CGS) have proved effective in 13 of 17 cases (76.47%) and partial or total calcanectomy in 15 of 17 cases (88.24%). The results assigned to bone involvement are summarized in table 3. Cure of infection has eventually been obtained in all cases with superficial and localized CO and in 10 of 12 cases with diffuse CO.

The assessment of functional results and walking ability has revealed that from 32 patients, 4 with spinal cord injury had been non-ambulatory prior to the treatment (table 1). From 28 ambulatory patients, 27 have retained the ability to walk after treatment. One patient has become non-ambulatory after amputation due to poor acceptance of prosthesis (elderly patient amputated due to CO complicating calcaneal fracture). In total, 13 of 13 (100%) patients who had been ambulatory before treatment retained the ability to walk after bone preserving operations and 14 of 15 (93.33%) patients who had been ambulatory before treatment were able to walk after partial or radical calcanectomies. 24 patients have required orthopedic device: shoe inlay (12), heel containment orthopedic shoe (11), prosthesis (1 of 4 amputated), whereas 4 non-ambulatory patients could do without an orthopedic device.

Discussion
Calcaneal osteomyelitis accounts for 7%-8% of all osteomyelitis cases in adults [1]. Hematogenous origin of CO is uncommon. The differential diagnosis includes tumors and tumor like lesions which may mimic CO [12]. Infectious process becomes apparent on plain radiographs when bone density drops to at least 60% [6]. Magnetic resonance imaging (MRI) findings include decreased T1 signal and increased T2 signal in the affected region, geographic pattern of bone destruction, abscess formation, cortical destruction and cellulitis [13]. The goal of therapy for CO is an infection-free foot with durable soft-tissue coverage and maximal preservation of function [2]. In children the treatment is mainly nonsurgical. In diagnostically clear cases it includes several weeks of antibiotic administration, initially intravenously and then orally [4, 6, 3]. In adults the surgery is more common and requires bone preserving procedures and skin flaps for soft tissue coverage or amputations. The surgical therapy for CO requires good balancing between the extent of bone resection and expected function. It acts towards eradication of infection within the bone and soft tissue, soft tissue reconstruction and preservation or reconstruction of the bone [7]. Local antibiotics provide high in situ concentration and – depending on their biocompatibility and time of action can contribute to preserving of the calcaneus. However, there are only few reports regarding local antibiotic application in CO therapy. The major disadvantage of the polymethylmethacrylate (PMMA) beads impregnated with gentamicin is the need of their surgical removal at the completion of antibiotic release. The biodegradable carriers like collagen-gentamicin sponge (CGS), hydroxyapatite blocks, polylactide/polyglycolide implants and the polylactate polymers release antibiotics at local concentrations exceeding those of the minimum inhibitory concentrations (MICs) for the most common pathogens of chronic osteomyelitis, without producing

Table 2. Results of surgical treatment assigned to type of operation.

<table>
<thead>
<tr>
<th>Type of treatment</th>
<th>Operation</th>
<th>Healing of infection</th>
<th>Failure</th>
<th>Total</th>
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</thead>
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<td>Bone preserving operations</td>
<td>Debridement</td>
<td>7</td>
<td>3</td>
<td>10</td>
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<tr>
<td></td>
<td>Drilling + CGS</td>
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<td>8</td>
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<td>Partial calcanectomy</td>
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<td>0</td>
<td>2</td>
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<tr>
<td>Total</td>
<td></td>
<td>28</td>
<td>9</td>
<td>37</td>
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toxic systemic concentrations and adverse effects [14].

The superiority of CGS over PMMA beads has been proven in clinical and animal studies [15, 16, 17]. Also calcium phosphate cements have proved to be a viable carrier of local antimicrobial agent allowing prolonged release of gentamicin sulfate or tobramycin [18, 19]. Depending on the extent of the infection within calcaneus and presence of skin defect, the spectrum of surgical procedures includes partial or total calcaneectomy and lower leg amputation. Skin defect, whenever present, plays crucial role in successful therapy of CO. Surgical decompression of active CO can be done either through the split heel approach (Gaenslen’s approach) or lateral approach [9]. Wounds up to 1 cm accompanying CO are suitable for Negative Pressure Wound Therapy (NPWT) or delayed primary closure. Local pedicled flaps like M. abductor digiti minimi flap laterally or M. abductor hallucis medially can be used [20]. If local muscle flap is not sufficient to close the defect, a free microvascularized flaps are indicated, preferably anterolateral upper leg flap [7]. Also distally based saphenous and sural neurofasciocutaneous flap can be used for wound closure after resection of infected part of the calcaneus [21]. Radicle debridement of infected part of the calcaneus requires either reconstruction or acceptance of the bone defect resulting after calcaneectomy. Del Pinal reported staged technique that preserves the bone shape in diffuse CO: removal of the whole spongy bone with preservation of the cortical shell and filling of the dead space using free muscle flap [22]. At the second stage autologous bone grafts are used for reconstruction of the calcaneus. Defects larger than 6 cm in diameter are regarded as unsuitable for filling up with cancellous bone grafts [7]. Free osteo-muscular flaps can also be used for reconstruction of the hindfoot after calcaneectomy like vascularized double barrel ribs combined with free serratus anterior muscle flap, free osteomuscular peroneus brevis flap as well as osteocutaneous flap including the medial femoral condyle [23, 24, 25]. Even distraction osteogenesis can be used to restore calcaneus after debridement for CO [26]. Partial calcaneotomy is preferred in CO with non healing ulcers and infected nonunions after calcaneal fracture as functionally more satisfactory and regarded as alternative to amputation. Partial calcaneal resection may be performed if the inflammatory process involves less than 50% of the heel [10, 11]. Functional and cosmetical results are better than after calcaneectomy or below-the-knee amputation [27, 28]. Total calcaneectomy is regarded as disabling and is indicated in CO involving more than 50% of the bone with accompanying skin defect not amenable to reconstruction and can be an alternative to transtibial amputation [7, 29].

After calcaneectomy complication like talonavicular subluxation has been reported, but 50% patients can maintain the same ambulation level postoperatively in a modified heel-containment orthosis [30]. Amputation should be considered if restoration of an infection-free foot covered with durable soft-tissue on plantar surface with satisfactory walking ability is unlikely, especially in patients with compromised skin sensation or motoric function [7].

The aim of the study has been to compare the effectiveness in eradication of the infection, walking ability and patient satisfaction with treatment after operations preserving the shape of the calcaneus and after partial or total calcaneectomy. Four operative procedures, differing by increasing surgical radicalism: debridement alone or with flaps, drilling and application of CGS, partial and total calcaneectomy have been performed in 32 cases. In total 37 limb sparing operations have been performed: 18 preserving the shape of the calcaneus and 19 less or more radical operations. In the assessed groups the difference in the cure rate of infections between bone preserving and radical operations (76,47% vs 88,24%) has been observed. It has been noted that bone preserving operations have been usually performed in cases with lesser destruction of the bone stock, which was not equivalent to bone involvement in MRI, and infection healing has been noted mainly, but not exclusively in less extensive cases of CO (table 3). In the study operations preserving the whole calcaneus were associated also with worse patient satisfaction with treatment as compared to the radical operations (88,23% vs 100%) but with better walking ability after operation (100% vs 93,33%) in ambulatory patients. Attention has also been given to assessment of author’s bone preserving technique of drilling and introduction of CGS pieces into drill holes in the calcaneus. As far as the authors know, the technique described in the paper has not been reported previously as local antibiotic delivery and bone sparing procedure in therapy of CO. This technique seems to be a promising alternative to more radical treatment options for chronic CO, contributing to salvage of the calcaneus in 6 from 8 treated cases. On the other hand the application of hand-made acrylic cement spacer, containing low-dose of gentamicin in 3 “diffuse” cases with cavitory defect of the bone, following partial resection (debridement of cavitory defect) was not effective. Because temporary antibiotic-containing spacers have proved to be effective in periprosthetic infections, the role of antibiotic spacers in CO requires further studies. Radical calcaneectomy performed in 2 cases has proved to be clinically successful and functionally accepted.

The limitation of this study is a considerably low
number of cases representing each type of CO according to Cierny-Mader classification, resulting from the rarity of CO in our population. Also influence of infecting organism and subsequent systemic antibiotic treatment has not been analysed due to seemingly increased complexity of assessment, resulting in difficulty to draw conclusions.

Conclusions

As compared to partial or total calcaneotomy, bone preserving operations (debridement alone or with flaps, drilling and application of CGS) performed for chronic calcaneal osteomyelitis provided inferior infection control (76.47% vs 88.24%) and worse patient’s satisfaction with treatment (88.24% vs 100%) and almost comparable walking ability (100% vs 93.33%). Drilling of the calcaneus with application of collagen sponge containing gentamicin performed in chronic diffuse calcaneal osteomyelitis seems to be attractive alternative to partial or radical calcaneotomy for ambulatory patients with acceptable effectiveness and functional results.

Competing Interests

The authors have declared that no competing interest exists.

References


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