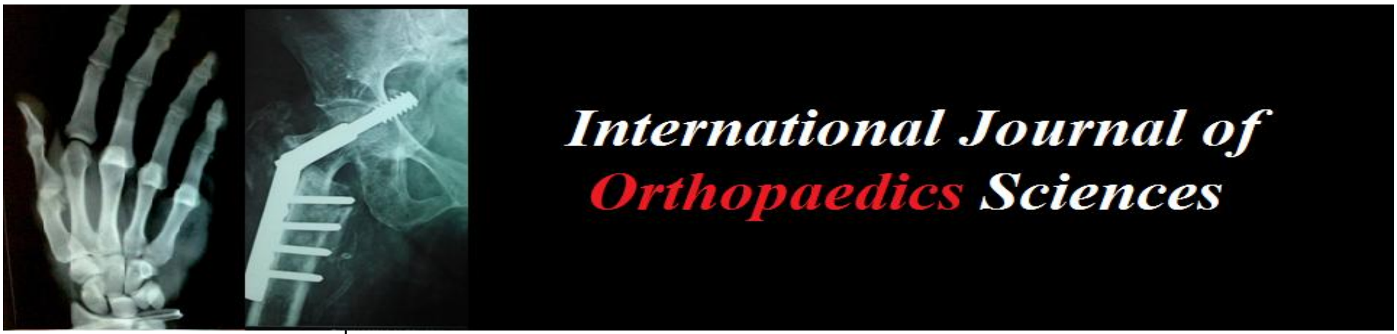

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Management of chronic osteomylitis by wide debridement and closed suction: Drainage technique

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Abstract
Background: Chronic osteomyelitis remains one of the most challenging problems in orthopaedic surgery [1-6]. It commonly occurs after sequele of acute osteomylitis in children and teenagers, secondary osteomylitis due to trauma involving either an open fracture or internal fixation [1].
Materials & Methods: This is prospective longitudinal study. We have prospectively studied 98 patients with chronic osteomyelitis treated by the technique of wide debridement and closed suction and drainage and describe the results at a mean follow-up of 21.96 months (min-max 20 to 24; median 22).
The procedure involved radical debridement and excision of all avascular scarred and infected granulation tissue, followed by debridement of the infected endosteum, reaming and the insertion of closed suction drainage system. The system rely on rapid fluid flow of 5 ml 10% povidon iodine in 500 ml normal saline and mechanical washing in association with appropriate intravenous antibiotic. The fluid used for drainage is normal saline and mixture of 5 ml 10% povidon iodine in 500 ml normal saline.
Results: Healing was achieved in all patient with fractures which had not previously united. There were three cases with recurrent infection with this procedure. Three patients required below-knee amputation due to eradication of the infection. These three patient had post traumatic osteomylitis. The mean follow-up was for 21.96 months (min-max 20to24;
Conclusions: The procedure of wide debridement and closed suction drainage is indicated for complex cases of osteomyelitis in which conventional surgical debridement have failed.

Keywords: Osteomylitis, Debridement, Suction, Drainage

Introduction
Chronic osteomyelitis remains one of the most challenging problems in orthopaedic surgery [1-6] It commonly occurs after sequele of acute osteomylitis in children and teenagers, secondary osteomylitis due to trauma involving either an open fracture or internal fixation [1] The event which heralds the transition from acute to chronic osteomyelitis is bacterial attachment to a functionally inert non-resorbable substratum, either a sequestrum or a foreign body [7]. In chronic osteomyelitis infected, dead bone lies within a compromised soft-tissue envelope [8]. Many regimes have been proposed for the treatment of chronic osteomyelitis including antibiotics [9-12], debridement and *en-bloc* excision [1, 13], staged management [14],closed irrigation and suction drainage [15-21] initially described by Smith-Petersen *et al* [20] in 1945, open bone grafting [2, 22-28] and mayoplasty [14, 29- 31].
The procedure involved radical debridement and excision of all avascular scarred and infected granulation tissue, followed by debridement of the infected endosteum, reaming and the insertion of closed suction drainage system. The system rely on rapid fluid flow of 5 ml 10% povidon iodine in 500 ml normal saline and mechanical washing in association with appropriate intravenous antibiotic. The fluid used for drainage is normal saline and mixture of 5 ml 10% povidon iodine in 500 ml normal saline.

Material and Methods
This is prospective longitudinal study. We have prospectively studied 98 patients with chronic osteomyelitis treated by the technique of wide debridement and closed suction and drainage and describe the results at a mean follow-up of 21.96 months (min-max 20to24; median 22).

There were 98 patient with chronic osteomyelitis in which 63 were children 20 adult and 15 old with a mean age of 23.85 (Median–16, Min-Max 12-57) years. According to the classification of Cierny and Mader [8] and Cierny [32], 93 were type-A and five type-B hosts with twenty eight type IV and seventy type III chronic osteomyelitis. (Figure I and II)

Anatomic type	
Type	**Characteristics**
I	Medullary osteomyelitis
II	Superficial osteomyelitis
III	Localised osteomyelitis
IV	Diffuse osteomyelitis

Physiological class	
Class	**Characteristics**
A	Good immune system and delivery
B	Compromised locally (B^L) or systemically (B^S)
C	Requires suppressive or no treatment; Minimal disability; Treatment worse than disease; Not a surgical candidate

Factors affecting physiological class	
Systemic factors (^{S})	**Local factors (^{L})**
Malnutrition Renal, liver failure Alcohol abuse Immune deficiency Chronic hypoxia Malignancy Diabetes mellitus Extremes of age Steroid therapy Tobacco abuse	Chronic lymphedema Venous stasis Major vessel compromise Arteritis Extensive scarring Radiation fibrosis

Fig 1: Cierny and Mader Classification system

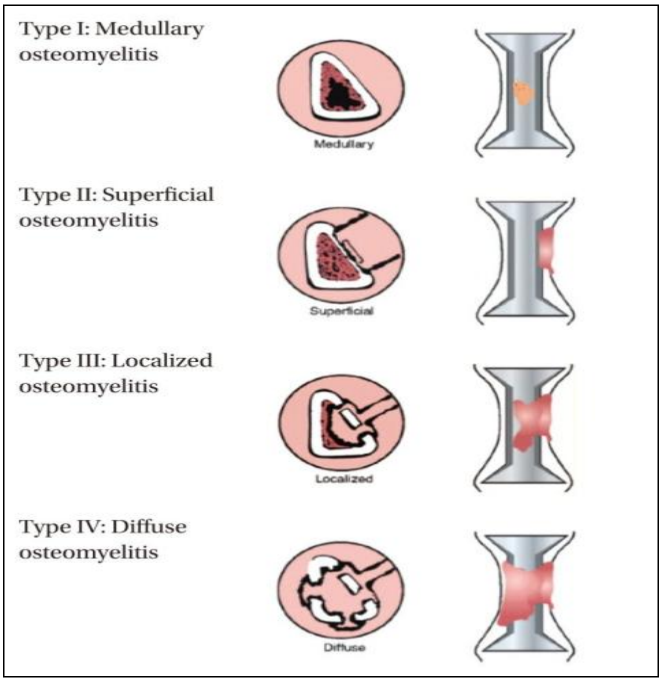

Fig 2: Cierny and Mader Classification for osteomylitis

These patients had received conventional antibiotic treatment at their primary hospitals. When first seen at our centre all had local signs of infection including a discharging sinus, dark pigmentation healed scars.

All underwent investigation including, a full blood count, measurement of the ESR and C-reactive protein and a microbiological profile. Plain radiography were performed on every patient. The diagnosis was made on the basis of clinical presentation and imaging, and confirmed bacteriological and histological from specimens obtained during the operation. The pre-operative blood indices are shown in Table I.

Table I: The pre-operative blood indices.

Test	Mean	Median	Range
White cell count (10^9/l)	14.93	15	4 to 21
ESR (mm/hr)	106.31	105	6 to 180
C-reactive protein (mg/dl)	62.91	65	5 to 168
Haemoglobin (g/dl)	12.04	12	10 to 15

Operative Technique

The anaesthetized patient is placed supine on a radiolucent operating table in a clean-air theatre. An image intensifier is available. Antibiotics are not given until adequate superficial and deep specimens have been taken for microbiological assessment. The approach for direct debridement of the affected segment of bone depends upon the location of the sinuses and where breeches in the cortex and sequestra are seen on the radiological studies. Scarred ischemic or necrotic subcutaneous tissue, deep fascia and muscle are excised along with sinuses and its tracts and obvious sequestra and dead bone are removed. When nonunion is present, necrotic bone ends are debrided and if necessary minimally resected. Adjacent cortical surfaces are ‘petalled’ as described by Colchero, Orst and Videal [33] to ensure viability. Multiple specimens are taken for aerobic and anaerobic microbiological culture and histology. The medullary canal is then reamed to remove debris from the endosteam and prepared for the insertion of the irrigation tubes. More extensive reaming may be indicated for the removal of necrotic tissue. Specimens are taken for microbiology and the canal is intermittently irrigated to prevent thermal injury.

At the end of reaming, Pass two tubes which are come along with suction drain into either end of the bone traversing the canal. The entry point of the tubes were variable according to clinical presentation of sinuses and sequestra but it is compulsory to put two tubes in the medularry cavity, one is for input and another is for output. The variable size of tubes were used to put in medullary cavity according to type of bone. The output tube was connected with a large suction drain which was used to drain effluent. The input tube was connected with central venous line which was used to deliver saline. The tubes ware carefully secured to the skin with sutures. Closed wound in layers. If wound cannot be closed seal it with adhesive plastic dressing. Plaster was applied to immobilise joints and prevent unnecessary movement where it was required. Further stabilisation, for example by external fixation, may be considered for non uninon post traumatic patient, but it may be technically difficult to achieve stable fixation without jeopardizing the irrigation system or increasing the risk of infection. For these reasons it was avoided until the tubes were removed and soft tissues and wounds had healed. Intravenous antibiotics were given for only fourteen day and orally for four weeks. The complete materials used for procedure are shown in Figure. III.

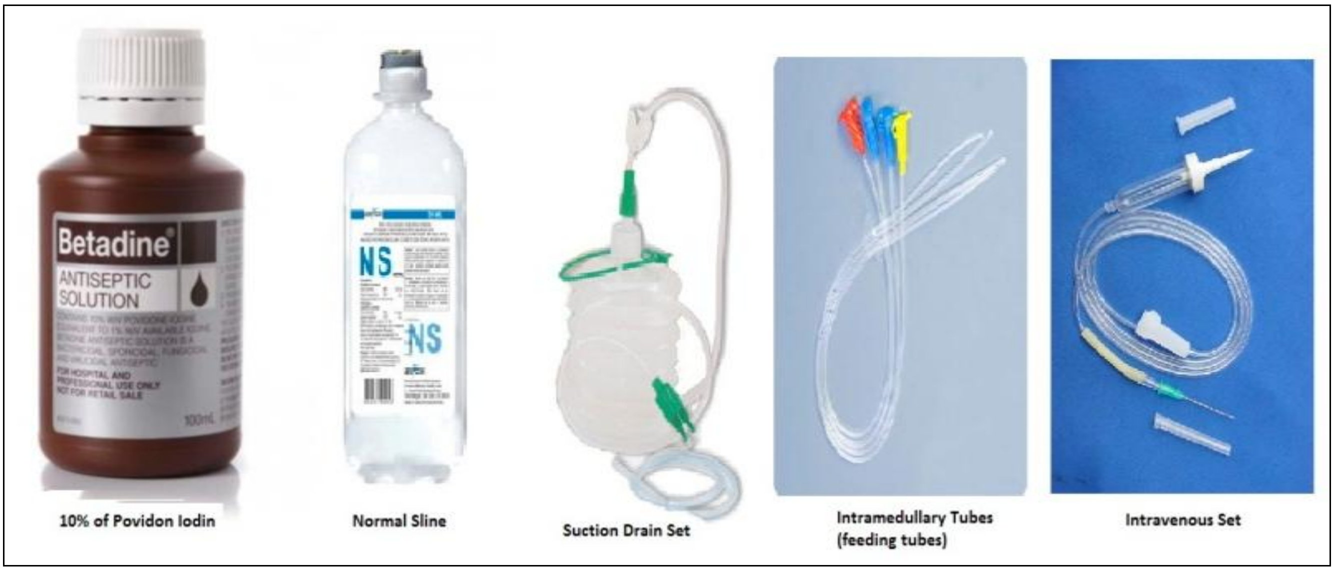

Fig 3: Material Used For Procedure

The medullary canal is irrigated with 9 to 12 litres mixture of 5 ml 10%povidon iodine in 500 ml normal saline at body temperature using suction drainage system for initial two postoperative days. The flow of the povidon iodine solution is ante grade for one day and retrograde on second day. Then irrigation and suction shifted to 9 to 12 liters of normal saline for next two day, one day ante grade and second day retrograde respectively. The irrigation tube is removed on fifth postoperative day and the drainage tube is removed on sixth post-operative day.

With this procedure, once dead tissue is excised and replaced with healthy vascularised granulation tissue and the dead space obliterated, these less virulent organisms are probably controlled by the body's own immune system. Blood tests including a full blood count and measurement of the ESR, C-reactive protein and urea and electrolytes are performed weekly.

Results

The mean duration of surgery was 1 to 3 hours. Majority of patients were children. There were 65 male and 33 female. The femur was involved in 35,tibia in 40, humerus in 13,radius in 4 and ulna in 6.(Fig. V) The etiology were sequele of acute osteomylitis in children and teenagers in 57 Cases, secondary osteomylitis due to trauma in 25 cases, postoperative & delayed postoperative in 16 cases.(Fig. IV) Intramedullary tubes were used in all cases. The patients were mobilised non-weight bearing at a mean of 8.8 days (median 9; min – max 7 to 11). The mean hospital stay was 25.05 days (min – max 20 to 30; 25 median). Complications encountered during treatment were pressure sores in four patient, local skin problems in one.

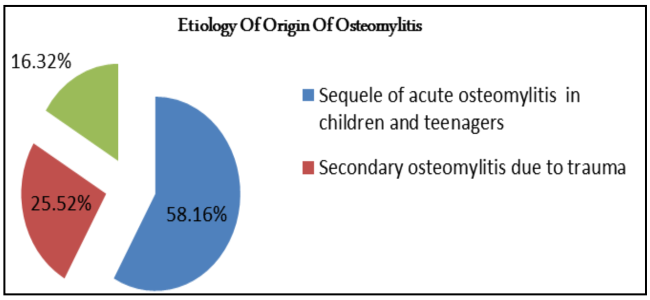

Fig 4: Etiology of Origine of Osteomylitis

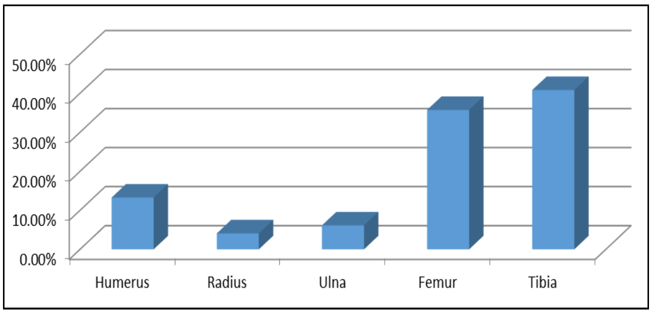

Fig 5: Involvement of Bone

When the infection had been cured, fifteen patients had further operations for nonunion of fracture including correction of deformity and definitive fixation .Healing was achieved in all patient with fractures which had not previously united. There were three cases with recurrent infection with this procedure. Three patients required below-knee amputation due to eradication of the infection. These three patient had post traumatic osteomylitis. The mean follow-up was for 21.96 months (min-max 20to24; median 22). The blood indices at the last review are shown in Table II.

Table 2: The post-operative blood indices

Test	Mean	Median	Range
White cell count (10^9/l)	7.51	8	4 to 21
ESR (mm/hr)	12	12	6 to 180
C-reactive protein (mg/dl)	9.56	10	5 to 168
Haemoglobin (g/dl)	10.87	11	10 to 15

Discussion

The management of chronic osteomyelitis is complicated by the presence of dead bone in a scarred soft-tissue envelope with a poor blood supply [8]. The criteria for treatment of chronic osteomyelitis include adequate debridement of necrotic, infected soft tissue and osseous structures [26, 31, 36, 37]; the preservation or creation of bony stability [13]; the ablation of dead space by packing and change of dressings, the use of methyl methacrylate, bone graft, closed suction irrigation, or muscle insertion [10, 13, 38, 39]; adequate antibiotic therapy [31, 38]; and appropriate soft-tissue cover [10, 14].

After debridement of soft tissue and bone a potential dead space is formed in which haematomas may collect [40]. Several approaches have been described to reduce the dead space including open [22, 23] or closed bone grafting [4], a local or free muscle flap [14] and closed wound irrigation with suction [15, 16, 20, 40]. The concept of wound irrigation in the management of chronic osteomyelitis dates back at least to 1917. [41] In 1945 Smith-Petersen *et al* [20] described local chemotherapy with primary wound closure. This idea was further propagated by Goldman *et al* [17], McElvenny [19], Compere *et al* [16] and Kelly *et al* [18]. All these authors 'saucerised' the infected area and assembled an irrigation system in the soft tissue adjacent to the saucerised bone. The intramedullary procedure of Weber and Lautenbach [21] has been used for infected total hip arthroplasties, but also for pandiaphyseal chronic osteomyelitis. This technique leaves the surgeon with precise control over the local environment of the wound. It allows close monitoring of changes in the bacterial flora and their sensitivities, which in turn enables delivery of high doses of specific antibiotics to be made into the medullary canal without systemic toxic effects [42, 43]. The cavity of the dead space is replaced by healthy vascular granulation tissue. An analysis of the published results of the closed irrigation/delivery systems is given in Table III [44].

Table 3: Details of published results of closed irrigation/antibiotic delivery systems

Authors	No. of patients	Duration of infection	Success (%)	Mean follow-up (mths)
Compere *et al* [16]	21		52.0 (71.4)*	30.0
Kelly *et al* [18]	40	68.7 mths	72.0	28.25
Clawson *et al* [115]	97	26.4 mths	73.0	16.0
Weber and Lautenbach [21]	33		88.0	72.0
Perry *et al* [43]	21		72.0	27.0
Koval et a [l6]	11		27.0 (45.50)	65.0
Meani and Romano [42]	10	1 to 5 yrs	88.8	33.7

* shows final result after revision surgery

Management of the dead space after debridement using antibiotic-impregnated beads was popularised by Bucholz in the early 1970s [45]. Walenkamp *et al* [44] described a series of 100 patients treated with gentamicin-polymethylmethacrylate beads, with a mean follow-up of five years and a success rate of 78% with a single treatment period comprising one to five operations. Cierny [32] described the use of customized antibiotic beads as the main tool for management of the dead space with an overall success rate of 92%, but with this technique the antibiotic could not be adjusted to changing sensitivities of the flora. Lautenbach [46] compared, prospectively, his technique with gentamicin beads and found that the results were better with a recurrence of 25% at the first treatment compared with that of 40% using beads.

Debridement, stabilisation and management of the cavity using bone graft and a flap have also shown good results (Table IV). Koval *et al* [6] achieved a success rate of 60% with primary debridement and flap cover, and their results improved to 80% after further operations. The 'Belfast technique' described by McNally *et al* [14] comprises a two-staged procedure. A radical debridement with soft tissue cover constituted the first stage, and in some cases gentamicin-impregnated beads were used. The second stage involved the use of an autogenous bone graft. There was are current deep infection in 13% of patients and 10% had problems with the wound needing further surgery. The overall success rate was 91%.

Table 4: Published results after debridement, stabilisation and management of the cavity

Author/s	No. of patients	Success (%)	Mean follow-up (mths)
Koval *et al* [6]	15	60 80*	48
McNally *et al* [14]	37	91	49
Swiontkowski *et al* [l9]	3	91	31
Cierny [53]	101	93	60

* shows final result after revision surgery

Swiontkowski *et al* [9] reported 93 patients who had had a single-stage aggressive surgical debridement with softtissue cover. In this group 41% needed antibiotic-impregnated beads, which were subsequently removed, 37% received a delayed autologous bone graft and 33% had a free tissue transfer.

Ilizarov introduced the concept that "osteomyelitis burns in the fire of regenerate", but Catagni's [48] experience has shown that although bone healing was achieved, infection was not always eliminated, with residual infection in 17.5%. He strongly advocated open debridement and *enbloc* excision as a bifocal procedure [48, 49]. The mean time in a frame was nine months. Saleh and Rees [50] employing bifocal surgery experienced a mean time of treatment of 16 months for bone transport and a cure of infection of 100%.

Marsh *et al* [51] described 22 patients with osteomyelitis, including 20 with nonunion, treated by the Ilizarov method with segmental excision and distraction osteogenesis. In this series three fractures failed to heal with the primary procedure and one patient needed a free flap. He reported complete cure of infection at a mean follow-up of 23 months. Ekkernkamp, Muhr and Josten [52] have shown elimination of infection in 94% of 71 patients.

The Ilizarov technique using *en-bloc* excision and transport has given excellent results but it needs a specialist team with a multidisciplinary approach and usually prolonged treatment time [48, 49].

The patients in this study had established chronic osteomyelitis. Majority were children and had osteomylitis due to sequele of acute osteomylitis. Using the closed suction and drainage technique in association with wide debridement and appropriate antibiotic therapy we achieved a success rate of 96.94% with the primary procedure. All these patients remained free from infection. Three had amputations after the infection had been eradicated for other reasons.

Conclusions

The procedure of wide debridement and closed suction drainage is indicated for complex cases of osteomyelitis in which conventional surgical debridement have failed.

Patient Declaration Statement

We had not disclose any detail regarding patient's privacy policy.

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