

The Effectiveness of Ceramics for Treatment of Diabetic Foot Ulcers Infected With Multidrug-resistant Bacteria

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Abstract

Background: Infected foot ulcers precede about two-thirds of lower extremity amputations. Foot ulcers are now the most common diabetes-related cause of hospitalisation and are frequent precursors of amputations. As many of these ulcers are hard to heal, a number of novel wound treatment devices are now available to help heal them. One such product is the Cerdak Bioceramic WTD. It consists of sachets filled with sterile ceramic spheres with an average diameter of 0.7mm. They generate capillary suction forces, which absorb wound exudate along with bacteria. These waste products are separated from the wound and the formation of healthy granulation tissue is promoted at a faster rate.

Study design: Observational study including three patients with type 2 diabetes mellitus on insulin therapy, treated in our institution. The patients had grade 3B or higher ulcers over the plantar surface of the foot (University of Texas ulcer classification). All patients underwent debridement and tissue culture and showed the presence of multidrug-resistant gram-negative bacilli at the time of debridement, which were extended-spectrum beta lactamase (ESBL) positive.

The debrided wounds were treated with Cerdak wound treatment devices locally and with appropriate culture-sensitive antibiotics, except in one patient who was not able to afford treatment with the appropriate antibiotic because of its high cost.

Results

- Repeat wound cultures taken over the next week were negative for MDR bacteria.
- The wounds in all four patients showed good granulation tissue formation and were later grafted with SSGs.
- All four ulcers healed within two months.

Conclusion: The case studies show that the Cerdak Bioceramic WTD can be an effective weapon in the armamentarium against multidrug-resistant bacteria found in diabetic foot wounds when used in conjunction with good clinical practices, including good glycaemic control and offloading of the ulcer. Further research in this direction may be needed to define its role fully, as it has a unique mode of action (capillary action which physically removes the bacteria and exudates), which prevents development of bacterial resistance to bioceramics.

Description of cases

Case I

Mrs R, aged 60, was admitted with a plantar abscess, which developed after she had walked barefoot on a pilgrimage. Her HbA1C was 10, FBS was 424mg/dl and her total leucocyte count (TLC) was 28 000 at the time of her admission. She was initially debrided and about 50ml of pus was removed. As there was



Left: Day 5
Above: Day 15

deterioration of her condition with involvement of the third and fourth layer of muscles in the foot she underwent a repeat debridement four days later. All necrotic muscle was removed. Tissue culture showed that she was infected with ESBL-positive *Pseudomonas aeruginosa*, which was resistant to all antibiotics except imipenem and meropenem. As her financial condition did not permit us to use these anti-



Day 25



Day 40

biotics she was put on Inj chloramphenicol while we monitored her blood counts. As there was minimal granulation tissue and lots of exudate, even after four days post-operatively, it was decided to use Cerdak cavity. After the first application of Cerdak cavity, there seemed to be a marked reduction in the exudate produced by the wound.

Very soon the wound started to granulate vigorously and by day 30 was free from slough. Repeat cultures done in the second week were negative for the MDR bacteria. The patient underwent SSG on day 33 and was given suitable footwear.

Case II



Day 1

Day 10

Mr K, aged 81, diabetic and on insulin therapy for the past 40 years, presented with a three-month-old ulcer over the right heel. The



Day 35



Day 45

ulcer was 10 X 15 cm in size and was probing to calcaneum. The calcaneum was necrotic in some areas. He also had POVD (ankle brachial index was 0.56). He is a smoker and had borderline diabetic nephropathy. He also had bilateral foot drop due to bilateral common peroneal nerve palsy. The ulcer showed lots of slough. His FBS was 345mg/dl and his TLC was 19 000 at the time of admission. As the vessels were not revascularisable he was advised to undergo a below knee amputation at another hospital. The ulcer was thoroughly debrided and the calcaneum was curetted to healthy bone. Tissue culture showed ESBL-producing *Pseudomonas aeruginosa* sensitive to meropenem and piperacillin/tazobactam. He was put on parenteral piperacillin/tazobactam along with local application of Cerdak WTDs. His heel was offloaded. By day six the production of exudate was reduced and the ulcer showed some sprouting granulation tissue. Repeat culture done after 15 days showed no growth. The ulcer improved and was grafted after six weeks of treatment. Now the ulcer has healed and the patient is being mobilised in a moulded shoe with AFO.



Day 60

Case III

Mr M, aged 62, a diabetic for the past 25 years with CAD, CRF, old stroke and dyslipidaemia was admitted with gangrene of his left third toe with plantar space abscess. His FBS at the time of admission was 382mg/dl and his HbA1C was 8.5. TLC at that time was 15 000. The infection had spread to his first, second and third metatarsophalangeal joints. A transmetatarsal amputation with sloughectomy was done. Tissue culture showed ESBL-positive MDR *E coli* along with coagulase-negative staphylococcus. He was put on culture-sensitive antibiotics. His wound was looking pale over the first four days in spite of a haemoglobin of 12gm/dl, after which Cerdak dressings were applied. The ulcer started to granulate slowly.



Day 1



Day 6

Day 22

Repeat cultures done after two weeks were negative. The ulcer became fit for SSG after five weeks and SSG was done. The patient is now ambulant with appropriate footwear.



Day 55

Discussion

Characteristics of an ideal wound dressing:

- Maintains a moist wound environment
- Absorbs excess exudate
- Eliminates dead space
- Does not harm the wound
- Provides thermal insulation
- Provides a bacterial barrier

The effect of a moist environment and the removal of excess exudate on chronic wound healing further lead to:

- Less intense and less prolonged inflammation
- More rapid keratinocyte proliferation and migration
- Earlier differentiation of keratinocytes to restore cutaneous barrier function
- Increased fibroblast proliferation
- Increased collagen synthesis
- Earlier full thickness wound contraction

In measuring the clinical observations of Cerdak against the abovementioned published clinical outcomes, Cerdak seems to fit the profile of an 'ideal dressing'.

We have observed a slimy layer over the wound during dressing changes, which could indicate a thin layer of fresh exudates on the wound bed.

Summary

- The bioceramic dressing removes excess exudate.
- It promotes healthy granulation tissue formation.
- It is easy to apply.
- It is cost-effective, even in the Indian healthcare environment.
- It does not need frequent changes.

References on request.

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