Case series: the impact of NATROX® Oxygen Wound Therapy System on patients with diabetic foot ulcers

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Diabetic foot ulceration currently costs around £600–£700 million per year in the NHS alone (Diabetes UK, 2012; NHS Digital, 2016). Both in the UK, and globally, diabetes incidence is increasing apace with costs set to spiral in the coming years. Hyperbaric oxygen therapy was first used in the field of wound care in the 1960s, and the association between oxygen and wound healing has since been investigated further and applied to a range of wounds. This article examines the role of oxygen — the NATROX® Oxygen Wound Therapy System — in wound healing, and looks at the impact of increased oxygenation on ulcer healing through a case series where the NATROX system was used in patients with diabetic foot ulcers.

The presence of a wound increases the body's need for oxygen because healing wounds require a lot of cellular activity so that resistance to infection, angiogenesis, and collagen synthesis cross-linking and epithelialisation can occur (Castilla et al, 2012; Eisenbud, 2012). Oxygen is required to power all cellular pathways, converting glucose into adenosine triphosphate (ATP). With sufficient oxygen, one glucose molecule can produce 36 molecules of ATP, compared with during hypoxia (low oxygen) when only two molecules are produced.

Available oxygen treatments

Hyperbaric (meaning higher pressure) oxygen therapy was first used in the 1930s to treat divers suffering from 'the bends' (Yarbrough and Benke, 1939). The therapy was further developed to support patients undergoing cardiac surgery (Boerema et al, 1956), and to treat clostridial gas gangrene (Brummelkamp et al, 1961) and carbon monoxide poisoning (Smith and Sharp, 1962). The role of oxygen in wound healing has been well documented since the 1960s when it was discovered that patients with burns who received oxygen therapy for carbon monoxide poisoning had wounds that healed more quickly (Wada et al, 1965).

Hyperbaric oxygen therapy is delivered in a high-pressure chamber, that is not portable, so cannot be used to supply continuous oxygen therapy in a community or home environment. Furthermore, a hyperbaric oxygen chamber can only deliver oxygen treatment in short bursts, which mean that oxygen levels in the wound are raised for only a small percentage, typically 4.5%–6%, of a week (Winfeld, 2014).

More recently, more localised methods of oxygen therapy have been investigated, such as large pressurised cylinders of oxygen connected to a chamber or bag that surrounds the anatomical region of the wound. Localised topical oxygen therapy has been found to lead to improved healing without the need for full-body hyperbaric chambers (Tawfick and Sultan, 2009). However, this therapy is still cumbersome as it requires attendance at specialist units, which can be lifestyle and mobility limiting.

Ambulatory topical oxygen

The novel NATROX® Oxygen Wound Therapy System (Inotec AMD Ltd) represents a significant development in topical oxygen therapy, as it can provide a more practical mode of continuous oxygen therapy than a hyperbaric oxygen chamber

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Article points

1. For wounds to heal, oxygen is required to power cellular pathways for infection resistant, angiogenesis, collagen synthesis cross-linking and epithelisation
2. The novel NATROX® Oxygen Wound Therapy System (Inotec AMD Ltd) represents a significant development in topical oxygen therapy in a small, portable, light-weight, easy-to-use system
3. A case series across two UK hospitals involving 10 people with chronic, non-healing diabetic foot ulcers was carried out to study NATROX for 8 weeks
4. The most significant and relevant result from the case series was the reduction in wound size

Key words

– Diabetic foot ulcer
– Oxygen
– Wound therapy

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Figure 1. The NATROX® Therapy System (Wounds UK, 2017).

or localised topical oxygen system (*Figure 1*) as it is small, lightweight, portable and easy to use.

It has a small battery-powered electrochemical 'Oxygen Generator' (OG) to concentrate atmospheric oxygen and feed >96% pure humidified oxygen at a rate of around 13mL/hour through a fine, soft tube to a disposable Oxygen Delivery System (ODS) that is placed over the wound and is held in place by a conventional semi-occlusive dressing. The Oxygen Generator can be worn in a holster on the waist or above the calf, or is placed in a trouser pocket, thus enabling the patient to have normal mobility. It can also be positioned for comfortable use at night and is silent, thus ensuring patient compliance and facilitating continuous treatment.

The science behind topical oxygen therapy is growing and there is clinical evidence to show that NATROX has a role in managing DFUs, with early studies showing an improvement in would healing times (Yu et al, 2016; Wounds UK, 2017). A potential treatment pathway for NATROX has been developed (Wounds UK, 2017), which suggests that NATROX may be considered in patients who are likely to suffer from local or systemic oxygenation problems and whose wounds are deemed unlikely, or slow, to heal.

Case series

Addenbrooke's Hospital in Cambridge and St George's Hospital in London jointly carried out a 6-month case series involving 10 people with chronic, non-healing diabetic foot ulcers, who were studied using NATROX for a period of 8 weeks.

Method

People with diabetic foot ulcers were selected from those currently being treated by the multidisciplinary team in Addenbrooke's and St George's hospitals. They had previously all had a full diabetes and arterial assessment.

For patients to be included in the case study, the following criteria were met:

- No significant wound reduction despite best practice care for a minimum of 4 weeks
- Patients had to be able to change and charge the battery in the NATROX device.

Treatment regimen

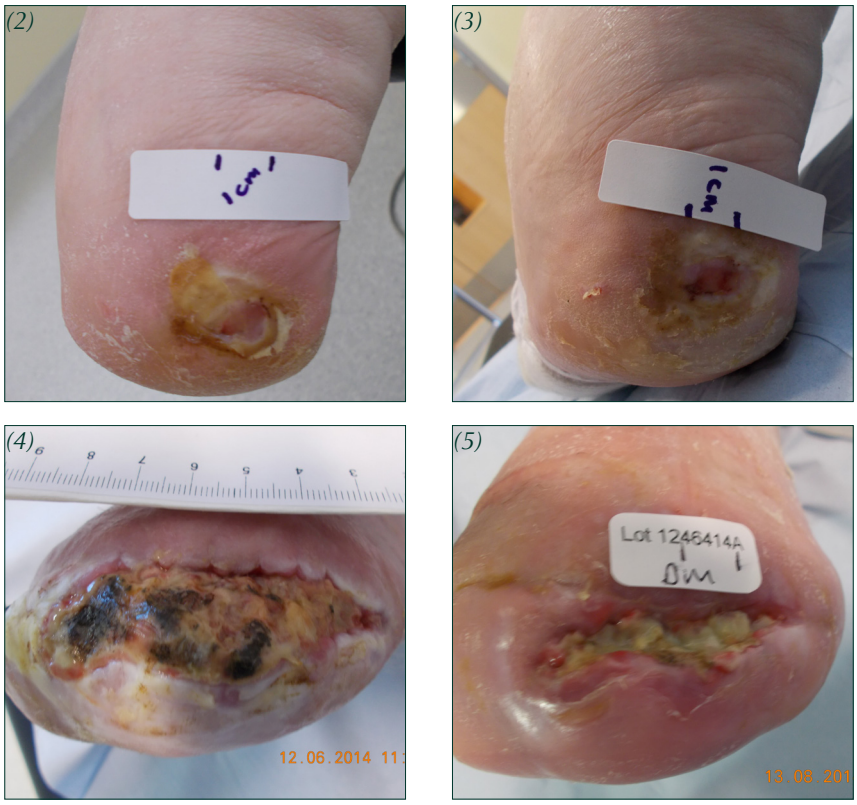
The disposable NATROX Oxygen Delivery System was placed directly onto the wound bed to optimise the diffusion of oxygen. The secondary dressing regimens were dictated by wound condition and hospital wound care formulary. However, for consistency during this study, patients were initially commenced on a silver alginate, absorbent pad and a dressing to secure this in place. If there were no signs of infection the dressing was changed to a standard alginate, absorbent pad and a dressing to secure this.

Patients returned to a specialist clinic every week and in between visits were treated by community nurses. Wounds were photographed digitally and measured, and all relevant consent and permissions gained. According to standard follow-up practice, each participant was followed up for 8 weeks.

Results

During this case series of 10 patients, the most significant and relevant result was the reduction in wound size, particularly in such a challenging group with wounds that had been deemed non-healing.

Of the 8-week study, the average reduction in wound size was 51%. Seven of the ten patients were on a healing trajectory, with one patient's wound healing completely. Here we describe two of the case studies.



Figures 2–5. (top left and clockwise). Figure 2: AF wound on 19.06.14; Figure 3: AF wound on 31.07.14; Figure 4: BL wound on 12.06.14; Figure 5: BL wound on 13.08.14.

Case study 1

AF is a 46-year-old woman. She has been insulin dependent since developing late-onset type 1 diabetes in 1998 and was diagnosed with peripheral neuropathy in 2004. On presentation, AF had an ulcer on her left heel, which had been present for 56 weeks and had failed to respond to standard treatment (including systemic and topical antibiotics) and advanced therapies, including negative pressure wound therapy. On average, AF was spending up to 8–11 hours a week attending clinic appointments, for which her husband was her main provider of transport. He also provided wound care in between hospital appointments, such as carrying out dressing changes as required. Prior to commencing NATROX therapy, distal pulses were checked and a full complement was confirmed.

The wound measured 0.56cm^2 (*Figure 2*), and while the patient had a degree of neuropathy, she did experience unpleasant sensations from her wound. The NATROX Oxygen Delivery System was changed twice weekly, once by AF's husband and once at the specialist clinic, thus AF only needed to attend clinic weekly.

By week 6, the wound had healed completely (*Figure 3*). AF found the device easy to use, non-invasive and comfortable. She commented that NATROX seemed to alleviate the unpleasant sensations she had experienced. She liked that she did not have to change her daily routine and stated that she was unaware of the presence of the NATROX device during her treatment.

Case Study 2

BL is a 76-year-old man with type 2 diabetes, which is managed with oral medication. BL has undergone a transmetatarsal amputation. When he returned to the Vascular clinic for his post-operative follow-up some weeks later, the wound had dehisced and he had a large, thick layer of black eschar covering the majority of the wound bed (*Figure 4*). He had previously undergone bypass surgery and, following a duplex ultrasound scan, which confirmed his bypass graft had failed, it was felt that there were no further surgical or endovascular options available to him.

Wound healing was necessary to avoid further higher amputation, which both he and the team responsible for his care were keen to avoid.

The non-viable tissue in the wound made the wound a less-than-ideal candidate for NATROX therapy; however, as there were very few options, NATROX therapy was commenced to achieve some degree of wound improvement.

During the 8-week treatment period, BL's wound responded positively to oxygen therapy as the wound reduced in size by 70% (*Figure 5*). Although complete wound healing was not achieved within the study period, his risk of further amputation had been significantly reduced.

Discussion

Each year in England, 7,300 people with diabetes have amputations (Public Health England, 2016) accounting for 80% of non-traumatic limb amputation (NICE, 2015); a procedure that can reduce quality of life substantially and is associated with high mortality (Goodridge et al, 2005). Studies suggest that 70% of people with diabetes who have had an amputation have

a 5-year mortality, which is the same for people with diabetic foot ulceration (NICE, 2015; NHS Digital, 2016).

An article by Kerr et al (2014) suggests that the total annual cost of diabetic foot ulceration in 2010–2011 was estimated at £580million, which accounts for 0.6% of the NHS expenditure in England. Of this expenditure, more than half was spent within primary, community and outpatient care, with the remainder spent within inpatient services for ulcer care and amputation (Kerr et al, 2014). Interventions that can potentially heal or greatly reduce the size of diabetic foot ulcers could reduce infection rates, amputations and associated costs, as well as improving overall quality of life. A device that can be utilised safely and easily by nursing staff and patients within the community environment could be a step in the right direction and may prove cost effective.

Conclusion

The vital role of oxygen in wound healing has long been acknowledged, and innovations in the method of delivery mark a potential new development in the application of topical oxygen therapy. Early evidence and these cases indicate the promising use of NATROX as a topical portable oxygen delivery system, which can be worn 24 hours a day, 7 days a week. The device is lightweight and discreet and can be applied easily — no intensive training is required, helping to promote patient acceptability and concordance. The experience of using NATROX in the treatment of diabetic foot ulcers may be extrapolated to a range of other wound types, as well as being developed to aid wound prevention in patients with a range of risk factors and reduce recurrence rates in patients with fragile skin. ■

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Declaration of interest

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