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Custom-made antibiotic cement nails: A comparative study of different fabrication techniques

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ABSTRACT

Introduction: The management of intramedullary long bone infections remains a challenge. Placement of antibiotic cement nails is a useful adjuvant to the antibiotic treatment of osteomyelitis. However, fabrication of antibiotic cement nails can be arduous. The purpose of this article is to introduce an easy and reproducible technique for the fabrication of antibiotics cement nails.
Materials and methods: We compared the time required to peel the chest tube off the 6 antibiotic cement nail using 2 different cement-cooling techniques and the addition of mineral oil in the chest tube. Additionally, we evaluated the optimal time to cut the chest tube (before and after cement hardening), consistency of nail's diameter, and the roughness of its surface. Cooling and peeling times were measured and failure was defined as a working time (from cement mixing to have a usable antibiotic cement nail) that exceeded 1 h.
Results: When the antibiotic cement nail was left to cool by convection (i.e. air-cooling), we failed to peel the plastic off the cement nail. When the chest tube was cut after conductive cooling (i.e. cold water-cooled), the cooling time was 10 min and the peeling time was 30 min without the use of mineral oil; the addition of mineral oil reduced peeling time to 7.5 min. Following peeling, residual adherent plastic pieces were found along the entire surface of the nail when no mineral oil was used. This was rarely seen when mineral oil was utilized to coat the inner layer of the chest tube.
Conclusion: Conductively cooling of the cement nail (in cold water) and pre-lubricating the chest tube with mineral oil are 2 tricks that render fabrication of antibiotic nail more efficient, reliable, and practical.

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Introduction

The management of intramedullary long bone osteomyelitis remains a challenge both for patients and surgeon. Treatment principles have barely changed since Cierny et al. initial description in 1983 [1]. These include: adequate surgical debridement, fracture stabilization, antibiotic administration, and soft tissue coverage [2–4]. Antibiotic cement nails offer the advantage of delivering high concentrations of antibiotics locally [5] and provide mechanical support and stabilization of the fracture. In 2002, Paley and Herzenberg published their preliminary results and technique [6]. Since then, several authors have reported on their experiences [5–13]. Numerous techniques for the intraoperative fabrication of antibiotic rods have been described including the use of a mould [11,12], manual rolling of the cement [10], or the use of a chest tube as a mould [5–9,13]. Chest tubes are cheap and readily available and provide a consistent shape. However, in our experience, removal of the chest tube from the hardened antibiotic nail has been a frustrating exercise. Our hypothesis was that heat from the cements exothermic reaction caused the plastic from the inner most layer of the chest tube to melt on the antibiotic cement nail. We aim to test our hypothesis by fabricating 6 antibiotic nails using a combination of 2 different modalities: variations in cement cooling method during the hardening/exothermic phase of the cement and application of mineral oil within the chest tube prior to cement insertion.

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Materials and methods

Our experiment was performed in an operating room environment at a standard temperature of 21 °C and humidity of 30%.

To test our hypothesis, we compared the time required to peel the chest tube from the antibiotic nail (i.e. time from cutting the chest tube to having a usable nail) using different cooling methods and the addition of mineral oil within the chest tube. Additionally, we evaluated the optimal time to cut the chest tube by comparing the peeling time between cutting the chest tube at the beginning of the cement exothermic reaction and after the cement had hardened/cooled.

For each antibiotic cement nails, we used a 40 French (Fr) chest tubes measuring 30 cm in length, a 3-mm beaded intramedullary guide wires measuring 32 cm in length, one pack of PMMA powder containing 0.5 g gentamicin, with the addition of 2 g of Vancomycin and 2.4 g of tobramycin per bag of Palacos (Palacos R + G, Zimmer, Warsaw, IN, USA), a 25 ml sterile mineral oil bottle used in 3 of the 6 nails (Geritrex Corp, Mount Vernon, NY, USA) and a water basin with cool sterile saline.

We fabricated 2 batches of 3 nails:

For the first batch of 3 nails we used a chest tube that was not coated with mineral oil. The first nail underwent "normal" convective air-cooling prior to peeling of the chest tube. The second nail was dipped in cold saline to undergo conductive cooling, thus dissipating the heat from the cement's exothermic reaction and preventing the plastic to be heated past its melting point. The third nail underwent convective air-cooling and the chest tube was peeled at the initial phase of the exothermic reaction.

The second batch of 3 nails was fabricated using the same protocol as the first batch but in chest tubes pre-coated with mineral oil (i.e. prior to cement injection).

The total working time to make the antibiotic cement nail consisted of: cement vacuum mixing time, cement injection time, guide wire insertion time, cooling time, and peeling time. Since the time from vacuum mixing (30 s) to guide wire insertion was the same in all 6 nails (5 min), we focused on measuring cooling and peeling times. Cooling time was defined as the time from the beginning of the exothermic reaction to the time where the antibiotic nail had reached body temperature. Failure was defined as a working time that exceeded 1 h. After peeling the chest tube off, we evaluated the consistency of the nail's diameter and looked at the surface of the nail to identify any residual plastic.

Results

The optimal timing to cut the chest tube

When the chest tube was incised at the beginning of the cement exothermic reaction (i.e. without the cement fully hardened) the cement was still sticky which did not allow it to separate from the chest tube during peeling. This resulted in a cement nail that was deformed and unusable (Fig. 1). The results were the same regardless of the use of mineral oil to coat the inside of the chest tube.

The effect of cooling method and mineral oil

When the chest tube underwent convective air-cooling, the cooling time was 21 min. After cooling, the chest tube was cut and the peeling time was over 34 min; therefore, we failed to peel the chest tube off from the cement nail, in a reasonable time (Fig. 2A). Additionally, the working time exceeded 1 h in both with and without the use of mineral oil (Table 1).

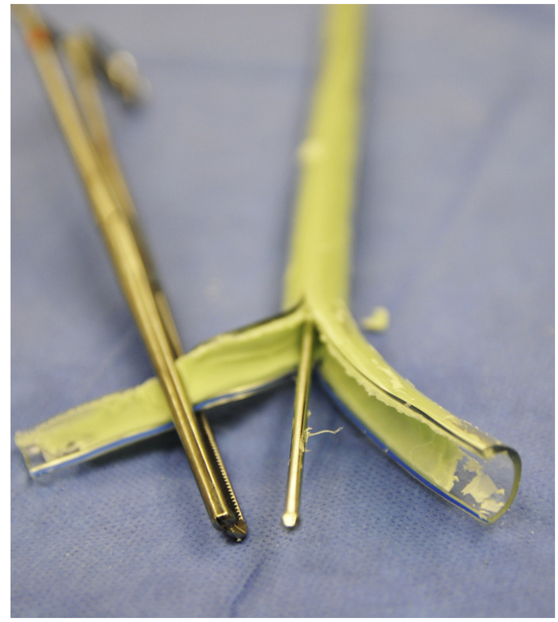

Fig. 1. Photograph depicting the deformed, split, antibiotic cement nail when the incision was made at the beginning of the cements exothermic reaction (i.e. without the cement being fully hardened).

When the chest tube was cut after conductive water-cooling, the cooling time was 10 min and the peeling time was 30 min without the use of mineral oil, and 7 min and 30 s with the use of mineral oil (Table 1). The diameter of the antibiotic cement nail was 9.3 mm and the cylindrical shape of nail of both water-cooled nails remained consistent regardless of use of mineral oil (Fig. 2B). The surface of the antibiotic cement nail had residual plastic chest tube pieces that had to be trimmed, before considering the nail usable (Fig. 3G). Without the use of mineral oil, the residual plastic pieces where found along the entire surface of nail. However, when mineral oil was used the residual plastic pieces were only found in the middle section of the antibiotic cement nail and were easily removable.

Suggested surgical technique

1. A chest tube is selected with an inner diameter similar to the patient's intramedullary canal, reamed canal goal, or outer diameter of the intramedullary device to be removed.

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   As a guide, the diameter of the antibiotic cement nail will be 9 mm when using a "standard" 38Fr chest tube, were an increase of 1Fr translates to an increase of 0.33 mm in nail diameter.
2. The chest tube is cut to the length of the nail being removed or the length of the tibia.

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   Throughout its length, the chest tube must not contain any holes so as to prevent cement leakage (Fig. 3A).
3. A 3-mm beaded intramedullary guide wire is cut to a length approximately 3 cm longer than the tube itself with the non-beaded end bent to make a hook or loop, making retrieval of the rod easier (Fig. 3A).
4. Two grams of vancomycin powder and 2.4 g of Tobramycin [14] are mixed together with one pack of PMMA powder containing 0.5 g of gentamicin (Palacos R + G, Zimmer, Warsaw, IN, USA) and a liquid monomer is then added.

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