Efficacy of new filter suction to decrease the rate of occlusion and total suction time in a simulated total hip replacement operation

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Background: During orthopedic operations, such as total hip replacement or total knee replacement, there is a lot of bone debris from bone cutting and reaming that commonly causes surgical suction devices to occlude many times, which can prolong the operative time and increase the amount of bleeding for the patient.

Materials and methods: We developed a surgical filter suction system that we call the VY suction tube. The suction tube assembly consists of a tube filter within a housing assembly. The filter pore size was designed to prevent tissue or bone debris from passing through the filter, though it allows fluid to pass through. A simulated total hip replacement operation was performed to test the efficacy of this new suction device when compared with two other types of tube suction devices.

Results: The VY suction tube showed that the mean duration to remove all fluid from a simulated field was significantly shorter than the Pool suction tube ($P=0.0009$) and Frazier suction tube ($P=0.0012$). The study also showed that the VY suction tube has a lower rate of occlusion when compared with the Pool suction tube ($P=0.0001$) and Frazier suction tube ($P=0.0001$).

Conclusion: Our new suction tube design shows good efficacy when removing fluid and debris from a simulated operative field. However, further studies in real clinical settings are needed.

Keywords: total hip replacement, filter suction, occlusion

Introduction

Surgical site infection is a devastating complication that commonly occurs postoperatively. A prolonged operative time is a risk factor of surgical site infection. One problem that surgeons face during an operation is occlusion of the surgical suction system due to tissue or bone debris, especially in orthopedic operations such as total hip replacement and total knee replacement. There is usually a lot of bone debris from bone cutting and reaming that frequently causes occlusion of the surgical suction equipment during an operation. In this study, we describe a filter suction system that was developed in our institute to solve the suction system occlusion problem. We also show the preliminary testing results of this filter suction.

Materials and methods

Design

The design concept was discussed between the physician and a design engineer before creating the three-dimensional models (Figure 1). The main concept was to decrease the occlusion rate of the suction system during operations. We developed a surgical filter suction tube that we call the VY suction tube. The suction assembly consists of a tube filter that is within the outer housing body, and that has inner and outer threads.
The filter pore size is small enough to prevent tissue or bone debris from going through the filter pores, but there are a sufficient number of pores that allow blood and body fluids to pass through without plugging the tube filter. The inner filter can be removed from the outer housing to clean tissue or bone debris from the filter. At the end of the inner filter there is a handle that is designed to grasp and easily remove the filter (Figure 2).

Simulated operation suction testing

This study was approved by the Ethics Committee and Institutional Review Board of the Faculty of Medicine at Prince of Songkla University (Songkhla, Thailand). Suction efficacy was tested by suction of bone debris and fluid from a simulated acetabular reaming procedure in total hip replacement. The acetabulum was harvested from a porcine cadaver for the simulated operation (Figure 3). The acetabulum was reamed with an acetabular reamer (Quickset® Graters; DePuy, Warsaw, IN, USA) and a pneumatic hand piece (PowerPro® 6150; ConMed Corporation, Utica, NY, USA) that started from sizes of 41–43 mm. The bone debris was collected for the next testing step. Fifteen grams of bone debris were placed in a 100 mL stainless steel bowl and mixed with 10 mL of sterile water. Bleeding was simulated by adding sterile water into the bowl at a rate of 1 mL/second by infusion pumps (Terufusion®, Terumo Corporation, Tokyo, Japan) for a total of 90 mL (Figure 4).

Five orthopedic surgeons tested and assessed the efficacy of the VY suction tube and compared it with the Pool suction tube (GF 862C; Aesculap, Tuttingen, Germany) and the Frazier suction tube (GF 925C; Aesculap) (Figure 5). Each of the suction tips was connected to a silicone tube (6.35 × 1.6 mm) and a vacuum suction bottle and vacuum regulator (Ohmeda Medical Surgical/Free-Flow Vacuum Regulator; Ohmeda Medical, Laurel, MD, USA). The suction pressure was set at 140 mmHg. All assessors used each suction tip two times separately to remove fluid in the simulated field. The suction tube’s efficacy was evaluated by the amount of time required to remove all fluid from the simulated field and the number of occlusions observed while the surgeons used the suction
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One reason why our VY suction tube exhibited better performance and a higher satisfaction rate when compared with the other tubes could be that the tip diameter of our suction device is bigger than the others, but it is not so big as to obstruct the visual operative field. The other reason for this finding is that the filter in this suction device could trap bone debris inside the suction housing, so the bone debris does not travel through the suction tube and into the reservoir bottle where obstruction can also occur if some bone debris becomes deposited there. An additional benefit of this suction device is the fact that it is easy to clean because all parts are removable for resterilization. In this way, this device should work in a real operation because it has a low occlusion rate and it is easy to use and clean.

Conclusion
This suction prototype was designed for an operative field with a lot of bone debris. However, it may also be applied to an operative field with a lot of soft tissue debris. Therefore, further studies in a real clinical setting should be done.

Author contributions
VY participated in the conception and design of the study, performed the data acquisition, participated in the statistical analysis, and drafted the manuscript. BT participated in the conception and design of the study, provided administrative support, carried out the critical revision of the manuscript, and supervised the study. TH and KI participated in the data acquisition and discussion of the results. All of the authors participated in drafting the manuscript.

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Disclosure
The authors report no conflicts of interest in this work.

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