Barbed Sutures for Arthroplasty Closure
Does it Decrease the Risk of Glove Perforation?

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Abstract
Recent resurgence in the interest of barbed suture has extended its application to wound closures in total joint surgery. Improved suture biomaterials and barb geometry has lead to consideration for its use in various orthopedic procedures including arthroplasty. The reported superior wound tensile stress distribution, no need for knots, and ability to close multiple layers with one suture make it an attractive option for deep wound closure after total joint surgery. However, inherent to the design of this suture are barbs that pose a risk of glove perforation and the potential for the transmission of blood borne pathogens. This study reports no increase in the incidence of glove perforation with use of barbed suture for deep wound closure after total joint arthroplasty.

Barbed sutures are experiencing resurgence in interest after almost 50 years of non-use.1,2 They were first described for flexor tendon repair in the 1960s, but interest quickly waned as the result of poor biomaterials and barb constructs of the time.3,4 Recent improvements in biomaterials and the expanded use of barbed suture by cosmetic surgeons for facelift procedures have led surgeons to reconsider the use of barbed sutures for a myriad of operations including arthroplasty.5,6 Each suture is a polypropylene monofilament specially engineered to form barbs in one or two directions that will anchor into and hold the soft tissue. The optimal barb geometry differs for different tissue applications and is determined by cut angle and cut depth.7 The reported advantages of a barbed suture include no need for knot tying and multiple suture handling, less operative room time, decreased suture material, well distributed tissue tension, and multiple layer closure.2,4,7 However, inherent to this suture construct are sharp barbs that are palpable when gripped with a double-gloved hand, which may cause glove perforation.

The rising incidence of HIV, hepatitis, and other blood borne pathogens among the general population make inadvertent exposure to a patient’s blood during surgery an increasingly important topic.8 Orthopaedic procedures involving bone cuts and fracture reduction represent the highest risk for glove perforation with reported rates ranging from 12% to 37.5%.9-13 Despite improved glove materials and the implementation of preventative measures, such as wearing double gloves, the rate of glove perforation in total joint surgery has been reported to be as high as 14.5%.13,14 The risk of seroconversion from superficial skin contact is relatively low; however, it is in every surgeon’s best interest to take all reasonable preventative steps to avoid exposure. Given the need for surgeon safety, this study evaluated the incidence of glove perforation, during total joint arthroplasty surgery, using a barbed suture compared to standard suture material. Our hypothesis was that a surgeon who closes the wound with a barbed suture would have a higher incidence of glove perforations.

Materials and Methods
We collected 122 gloves from 31 consecutive total hip and knee arthroplasty surgeries using No. 2 absorbable barbed suture material for deep fascia closure, and 50 gloves from 13 consecutive total hip and knee arthroplasty surgeries using No. 1 absorbable braided suture. These cases involved...
joint replacement fellowship trained attending surgeons and senior residents. Fascial closure was done with No. 2 polydioxanone monofilament Quill® barbed suture (Angiotech, Vancouver, British Columbia, Canada) or No. 1 polyglactin braided Vicryl® suture (Ethicon, Johnson and Johnson, Somerville, New Jersey, USA). All gloves were utilized for the deep closure only and were collected prior to the superficial closure.

Quill PDO® is an absorbable polydioxanone monofilament with bidirectional barbs that pull through tissue in one direction and catch in the opposite direction. The forces applied by the suture are distributed across the length of the suture and the barbs, thus distributing the tension across the entire length of the closed tissue (Fig. 1).

We used a previously validated electroconductivity protocol for glove integrity testing. Shohn and associates described the increased accuracy and sensitivity of the electroconductivity test compared with the water load test in detecting surgical glove tears.

Ten pairs of unused powder-free latex gloves were used to validate our experimental model. Each glove was tested separately by visual inspection for tears. Each glove was filled with 500 cc normal saline and immersed in a one-liter saline solution bath. An Ohm meter (Radioshack Cat # 22-108) was used with the negative electrode placed inside the glove, and the positive electrode placed in the bath (Fig. 2). No current was detected in all 20 gloves indicating that the integrity of the gloves was not compromised. Percutating each glove’s index finger with a small diameter-cutting needle completed the second stage of the validation. All the gloves were retested and current was detected in all 20 gloves (Fig. 2).

Two surgeons, one attending and one resident, were involved in every case. All surgeons used double powder-free gloves (Ansell, Dothan, AL) in all cases; surgeons exchanged their outer gloves just prior to barb suture handling and removed the gloves immediately upon completion of the suture handling. All gloves were collected, and the type of suture material noted. No patients were excluded from taking part in the study during the study time period; both cohorts were consecutively collected starting with the barbed suture cohort and followed by the braided suture cohort. Both cohorts were used by the same group of physicians.

Technique for deep facial layer closure with barbed suture was conducted as follows: closure was started at the mid portion of the wound; the barbed suture was passed once and aligned together by placing both needles together. Afterward, two loose passes with each needle were done,
followed by firmly gripping each end and manually pulling on both sides of the suture, which approximates the wound edges and locks the suture in place. Running each side of the suture and manually tightening after each turn completed the wound closure. The ends were secured by employing a few backstitches. When the fascial layer closure was completed, the edges were cut off. Closure with the standard suture was performed with figure of eight knots. All surgeons underwent an instructional session about proper barbed suture use prior to the study.

Postoperatively, the gloves were taken to the laboratory and visually inspected for any perforations. Each glove was filled with 500 cc normal saline and visually inspected again for any tears or saline leaks. The glove was then placed into a 1 liter saline bath and tested for tears via the above mentioned electroconductivity protocol (Fig.1). A positive test was defined as the presence of any observed electrical current.

Statistical analyses were performed with a 2-sided Fischer exact test with statistical significance defined as p < 0.05. Data analysis was done by use of the GraphPad INSTAT statistical package (GraphPad Software, San Diego, CA). Post-hoc power analysis revealed that the study had over 95% power in detecting a difference of more than 1% in perforation rate among the groups.

Results

A total of 44 operations were studied. In all cases, the fascia was observed to be well opposed without any gapping or suture pullout. It was during the manual-tightening phase of the repair that the barbs were felt by the surgeons, though without any obvious signs of bleeding or glove tearing. One hundred and seventy-two outer gloves were tested, no visible tears were seen during the initial inspection, and no visible tears were seen during the second visual inspection performed after the gloves were filled with normal saline.

Among the gloves used with barbed sutures 17 of the 122 (13.93%) were found to be positive for tears by electroconductivity testing in the normal saline bath; among the control gloves, 9 of the 50 (18.0%) were found to be positive for tears. There was no statistically significant difference (p = 0.4908) between the rates of glove tears between the two study groups.

No finger lacerations were noted during the testing period among the surgeons in the study. None of the surgeons that were found to have tears in their gloves were aware of glove perforation or needle punctures during the surgery. However, all surgeons reported possibly feeling a tiny puncture while handling the barbed sutures during closure. All intraoperative glove perforations went undetected and unrecorded by the operating room personnel.

Discussion

Intraoperative glove perforation is an important consideration during surgery and is a constant occupational hazard in orthopaedic surgery in particular.10,11 Glove integrity remains an important and integral part of patient and surgeon safety during orthopaedic surgery. Thanni and coworkers examined 71 orthopaedic operations and observed a perforation rate of 12%, which was similar to other recent studies that observed perforation rates of 5% to 17%.10,13,14 Some older studies reported rates of glove perforation as high as 26% to 37%.9,11 The incidence of perforation of the inner glove and subsequent exposure to the patient’s blood has been shown to be as low as 2% when an outer glove is worn.13

Viral transmission in the operating room is correlated with the volume of the inoculums, depth of penetration, and frequency of exposure. The current literature estimates that surgeons have a high lifetime risk of being exposed, due to glove perforation, to hepatitis, and HIV viruses.17-19

The incidence of orthopaedic surgeons treating HIV positive patients, especially arthroplasty surgeons, is increasing with the aging population and improvements in HIV-treatment.1 Sim and colleagues discussed the utilization of the “no touch technique” and the development of instrumentation that will allow the reduction of in the use of sharp instruments during surgery.17 He had discussed this concept more than 20 years ago. Nonetheless, sharp instrumentation and bone ends remain essential hazards to the orthopaedic surgeon. Palmer and associates reported a 13% incidence of skin damage in the hands of operative personnel, further highlighting the importance of adequate intraoperative protection.19 Surgical wound closure continues to rely heavily on conventional suture knots, which requires operator expertise with suture handling and time. Barbed suture allows wound closure using a self-anchoring suture that avoids the need for knot tying and multiple suture handling.

In this prospective study, we examined the incidence of glove perforations using both a novel barbed suture technique and standard suture for deep fascia closure in arthroplasty surgery. We found a 13.9% and 18.0% rate of outer glove perforation respectively. Rather than decreasing the rate of possible glove perforation by eliminating the need for multiple needles and suture handling during deep fascia closure, the barbed suture led to the same rate of perforation of the outer gloves during handling and wound closure as the standard suture technique. The study design isolated the effect of using different suture techniques on glove perforation by requiring the surgeons to replace their outer gloves just before handling the suture and to remove them for collection immediately after closure.

Several limitations are present in this study. We did not quantify the prevalence of inner glove perforation due to the increased difficulty of maintaining a sterile operative field while exchanging the inner gloves during surgery. In addition, we chose to use only one type of gloves during the study. Even though the surgeons underwent instruction about proper usage of the barbed suture, we did not oversee the exact technique used in the operating room, and improper use could have happened. We think that the technique used
by the surgeons in this study represents the average surgeon
technique in the community and thus represents the actual
outcome of barbed suture use.

Based on our findings, we recommend performing mul-
tiple intraoperative glove changes and to consider using
cotton gloves as an extra layer of protection during ortho-
paedic procedures. Future research should be directed into
integrating new surgical technologies that not only increase
operative efficiency but that also increase the surgeon’s
safety in the operating room.

**Conclusion**

Arthroplasty surgeons have a high inherent risk for contami-
nation due to the use of sharp edged instruments and bone
ends during surgery. As shown in this prospective study,
intraoperative glove perforation occurs with high frequency
when both barbed and standard suture techniques are used
for closure of the deep fascia. Awareness of this risk may
benefit the surgeon when choosing his method and technique
for wound closure.

**Disclosure Statement**

None of the authors have a financial or proprietary interest
in the subject matter or materials discussed, including, but
not limited to, employment, consultancies, stock ownership,
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