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A prospective analysis of glove perforation in primary and revision total hip and total knee arthroplasty.

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Abstract:

Literature in regard to glove perforation rates in revision total joint arthroplasty (TJA) is scarce. Our purpose was to determine the incidence of perforation in revision TJA. Gloves from all scrubbed personnel were tested based on the American Society for Testing and Materials. A total of 3863 gloves were collected from 58 primary and 36 revision arthroplasty cases. Surgeons had a 3.7% outer-glove perforation rate in primary TJA compared with 8.9% in revision TJA. When both gloves were perforated, the outer-glove perforation was recognized intraoperatively 100% of the time, and the inner-glove perforation was noted only 19% of the time. The surgeon has the highest rate of glove perforation. Outer-glove perforations should prompt careful inspection of the inner glove.

Keywords: gloves, perforation, total joint arthroplasty revision, latex, nonlatex.

Introduction:

The number of total joint arthroplasties (TJAs) performed in the United States has been steadily increasing [1]. The incidence of infection has been reported to be 0.88% to 0.92% for primary arthroplasty and 2.9% to 30.2% for revision arthroplasty [1–7]. It is expected that more patients will be diagnosed as having periprosthetic joint infection (PJI) in the future; secondary to this rise is the volume of procedures. The etiology of PJI is multifactorial and can be categorized as patient related, surgical, and postoperative. Higher comorbidities such as diabetes and obesity are examples of patient-related factors. Surgical factors include operative time, bilateral procedures, total knee arthroplasty (TKA), and allogenic blood transfusion [8]. Postoperative complications such as atrial fibrillation, myocardial infarction, urinary tract infection, and longer hospital stay have also been associated with an increased risk of PJI [8]. Surgeons often concentrate on perioperative strategies to reduce the risk of PJI. The use of body exhaust systems, laminar airflow, and prophylactic antibiotics are examples of commonly used techniques [8–10]. Basic, strict aseptic technique is essential to reduce the risk of contamination of the surgical field. Glove perforation during any surgical procedure is of concern because it increases the risk of disease transmission to both the patient and medical personnel as well as contamination of the surgical field.

Several studies have reported the incidence of glove perforation during orthopedic procedures to be between 3.6% and 26% [11–18]. Prior studies have demonstrated an association between glove perforation and duration of the procedure, hand dominance, and specific portions of the procedure [11,12,14,19]. The incidence of glove perforations in primary TJA has been previously reported [11,20–22]; however, the authors are unaware of any published studies that specifically examine the incidence of glove perforation in revision TJA.A prospective,

comparative study was designed to evaluate the incidence of glove perforation in primary and revision TJA.

The primary objective was to determine the incidence of glove perforation in revision TJA as compared with primary TJA. The secondary objective was to determine the factors that influence glove perforation. Our hypothesis was that the rate of glove perforation in revision TJA is greater than that in primary TJA.

Patients and Materials:

All gloves worn by scrubbed operating room personnel during primary and revision total hip arthroplasty (THA) and TKA were collected from October 28, 2009, to May 21, 2010. At our institution, a triple-gloving protocol is used. The third ("prep") layer of gloves is worn by scrubbed personnel for draping purposes and then discarded before incision. Esteem nonlatex (Cardinal Health Inc, Dublin, Ohio) gloves are routinely worn during draping. The second layer of gloves ("outer" after prep layer discarded) is worn from the time of initial incision and is changed as needed throughout the case. This outer layer of gloves is Esteem nonlatex, or Biogel nonlatex (Mölnlycke Health Care, Gothenburg, Sweden), or Triflex Orthopaedic (Cardinal Health Inc) latex gloves. This layer of gloves is chosen at the discretion of the scrubbed personnel. The first ("inner") layers of gloves are worn from the time the person scrubbed in to the case until the person scrubbed out, unless a perforation was noted. These gloves are either Esteem nonlatex or Biogel nonlatex gloves.

Data were collected regarding operating room personnel and the type of surgery before the start of the procedure. This included the person's role during the case, hand dominance, and the time the person scrubbed into the case. Informed consent for this study was obtained from all

personnel before the case. At the time of glove removal, the glove material, side, layer, duration of the glove wear, time during the procedure the glove was removed, and reason for glove removal were recorded. The gloves were individually labeled and placed in marked numbered plastic bags. All gloves were counted individually and not as a pair. At the conclusion of the procedure, all gloves were reanalyzed for perforations. The gloves were tested with a standardized water infusion method following the American Society for Testing and Materials guidelines on determining perforation in gloves [23]. The gloves were filled with 1000 mL of water and suspended from the occluded cuff, 5 ft from the ground. The gloves and the digits were pressurized, and all perforations were identified by a jet of water [23] (Fig. 1). Perforations, if any, were noted along with location, size, number, and cause of perforation (if known).

Statistical analysis was conducted to determine if a significant association with the measured factors and perforation existed using the Fisher exact test for incidence rate less than 5% and $\chi 2$ test for categorical variables with incidence rates greater than 5%. Twotailed unpaired t test for continuous variables was used, and P values less than .05 were considered statistically significant.

Results:

Three thousand eight hundred sixty-three gloves were collected from all scrubbed personnel during primary and revision total TJA at our institution. The gloves were collected from 58 primary (2 bilateral THA, 1 bilateral TKA) cases and 36 revision cases. The incidence of glove perforation was 4.3%(166/3863 gloves) if all gloves were included. The incidence of glove perforation increased to 4.7%(144/3047 gloves) if all prep gloves used during the preparation and draping portion of the procedure were excluded. Furthermore, we examined the

gloves of the personnel performing the parts of the procedure most at risk to perforation: the attending surgeon, adult reconstruction fellow, and the registered nurse first assist (RNFA). Second assist and scrub nurse/technician perforation rates were also noted (Table 1).

The attending surgeon had a 4.0% (22/542 gloves) combined outer- and inner-glove perforation rate in all cases. Outer gloves perforated in 5.5% (19/342 gloves), and inner gloves perforated in 1.5% (3/200 gloves) (Table 1). The attending surgeon's outer glove was perforated in 3.7% (8/219 gloves) of primary TJA compared with 8.9% (11/123 gloves) in revision cases (P = .04) (Table 2). Outer latex gloves had a perforation rate of 6.5% (12/185 latex outer gloves) compared with 4.5% (P = 41) in primary and revision surgeries combined (Table 2).

The attending surgeon, fellow, and first assist are most at risk to perforation during the surgical procedure; therefore, data were combined and analyzed (Tables 1 and 2). The combined outer- and inner-glove perforation rate in this group was 6.6% (109/1649 gloves). The overall incidence of perforation of the outer layer was 7.7% (82/1062 gloves). Outer-glove perforations occurred in 7.8% (49/626 gloves) worn during primary TJA compared with 9.4% (41/436 gloves) in revision TJA (P = 36). The inner layer was perforated in 4.6% (27/587 gloves) of all TJA cases. Outer latex gloves had an incidence of perforation of 9.4% compared with 7.3% for nonlatex gloves (P = 29) in primary and revision surgeries (Table 3).

Perforations among the attending surgeon, fellow, and first assist were noticed only 33.1% (39/118 gloves) of the time (Table 4). Furthermore 2.5% (42/1649 gloves) of gloves worn in this group had glove perforations that penetrated both the outer and inner layers. In all of these instances, the outer-layer perforation was noticed by the personnel intraoperatively and the glove was changed. The inner-glove perforation, however, was only noticed 19% (4/21 inner-glove perforations) of the time and was subsequently changed during the procedure.

In primary and revision TJA cases combined, 40% of the perforations occurred from exposure to resection of bone and before implantation of the final components. Most (79.6%) of the gloves perforated from the time of exposure through implantation of the final components. There was no significant difference in the time of perforated outer gloves worn by the attending surgeon, fellow, and first assist (mean ± SD, 46.1 ± 35.5 minutes) compared with nonperforated gloves (mean ± SD, 42.6 ± 44 minutes) (t0.71 = 1026, P = .48). Excluding gloves changed for recognized perforations, outer gloves were changed a total of 596 times before implantation of the final components, with an average duration worn of 45.5 minutes. Gloves from implantation to the time of scrub out were worn an average of 39.2 minutes. Fifty-five percent of perforations occurred on the index finger, followed by 16.5% on the thumb. Sixty-five percent of perforations occurred on the nondominant hand.

Discussion:

Maintaining the barrier between the operating room personnel and the patient is a vital component to any surgical procedure because it reduces the risk of disease transmission and subsequent infections. Glove perforations increase the risk of infection for both the surgical team and the patient [24–27]. This study is the first to demonstrate the incidence of glove perforation during revision TJA. Furthermore, the rates of perforation during primary and revision TJAs were of sufficient incidence to be of concern, and the perforations were not noticed by the operating room personnel in most cases.

Overall, there was a 6.6% risk of glove perforation among the attending surgeon, fellow, and RNFA when double gloved during primary and revision TJAs. The outer layer was perforated in 7.7%. Previous studies have reported a broad range of perforation rates in THA and

TKA, ranging from 6.8% to 14.6%, depending on the operating room personnel studied and glove layer [17,28]. The outer and inner layers were both perforated in 2.5% of gloves from the surgeon, fellow, and first assist. All outer-glove perforations were noticed when the puncture penetrated both layers. However, after the personnel noticed the outer-glove perforation and changed the glove, the inner-glove perforation went unnoticed 81% of the time. This is of particular concern for the person wearing the glove because this can increase the duration of exposure to a potentially biohazard material.

A similar study performed over the course of 120 hip fracture operations found that with double gloving, the surgeon is less likely to be aware of perforations of the outer glove [29]. This does not explain the high rate of unnoticed inner-glove perforations found in this study. Personnel with noticeable glove perforations should change their inner glove or examine the inner glove closely before regloving with a new outer layer.

There was a significant increase in the incidence of perforations for the attending surgeon during revision TJA as compared with primary TJA. This is not surprising because of the increased complexity of revision TJA, exposure of the surgeon to sharp bony and metal edges, and increased duration of surgery. There was a statistical trend toward a higher incidence of perforations in revision TJA as compared with primary TJA in this study for the first assistants, namely, the arthroplasty fellow and the RNFA. Failure to reach statistical significance when combining personnel may have been attributed to the variability in revision THA and TKA or insufficient numbers to power this study.

Previous studies have demonstrated that orthopedic surgeries are at higher risk for glove perforation than other surgical specialties [30,31]. Consistent with previous literature, glove perforations were also more prevalent during the critical portions of the procedure, primarily

from the time of exposure to implantation. Yinusa et al [14] reported that the numbers of glove perforations increase during bony procedures and with procedures that require more instrumentation. Similarly, Nicolai et al [17] found a higher number of perforations during preparation of bone before implant fixation.

The outer-layer glove perforation rate at our institution was 7.7% among the attending surgeon, fellow, and RNFA. In TJA cases, the latex perforation rate reportedly has ranged from 8.4% to 13% [21,28,32]. Aldlyami et al [32] compared latex and nonlatex gloves during primary TJA and found nonlatex gloves to have a higher perforation rate. In our analysis, there was no significant difference between latex and nonlatex gloves. This could be due to differences in the quality of the newer nonlatex gloves or that this arm was underpowered due to a smaller sample size.

This study has several limitations. Assessing when unnoticed perforations occur is impossible to accurately determine. As a result, only ranges of time periods when the unnoticed perforations occurred could be determined. Another limitation is that the water infusion method creates noticeable distention of the glove, causing the jet of water to exit the perforation. These distention and oversaturation prevent the natural selfsealing elastic properties of these gloves, which can decrease exposure [33,34]. Pressurization also may have caused perforations in the gloves where the structural integrity was compromised but where no true perforation existed before testing. Glove removal can also be a contributing factor to perforations; therefore, it is important to recognize that a minimal number of perforations may have occurred due to this reason.

There was no appreciable difference in the time worn between perforated and imperforated outer gloves. This discrepancy could be due to the fact that gloves were worn, on

average, for less than an hour secondary to routine changing of gloves during the procedure. Two studies reported that the incidence of glove perforation increases as the duration of the glove wear lengthens [21,31]. Most glove punctures occurred on the nondominant hand and most commonly on the index finger. Previous studies support these findings as well [14,29,35].

The risk of glove perforation, irrespective of glove material, is still of concern. Disease transmission or contamination between operating room personnel and the patient is worrisome because most of these perforations go unnoticed. Increasing the awareness of possible double-layer perforations during TJA procedures may decrease the risk of disease transmission or PPI. When a perforation is noticed, removal and arthroplasty of the underlying glove or careful inspection before regloving with a new outer layer is warranted.

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Fig. 1. Water infusion method for detection of glove perforations.

Table 1. Glove Perforations

	Perforations	Total	%
Surgeon			
Prep gloves	1	81	1.2
Outer gloves	19	342	5.5
Inner gloves	3	200	1.5
Fellow			
Prep	5	213	2.3
Outer gloves	49	421	11.6
Inner gloves	18	209	8.6
RNFA			
Prep gloves	3	171	1.8
Outer gloves	14	299	4.7
Inner gloves	6	178	3.4
Scrub nurse			
Prep gloves	7	111	6.3
Outer gloves	11	499	2.2
Inner gloves	9	195	4.6
Surgeon/Fellow/RNFA			
Prep gloves	9	465	1.9
Outer gloves	82	1062	7.7
Inner gloves	27	587	4.6

Table 2. Latex vs Nonlatex

	Perforations	Total	%	*P*
Surgeon				
Latex	12	185	6.5	
Nonlatex	7	157	4.5	.4
Surgeon/Fellow/RNFA				
Latex	22	235	9.4	
Nonlatex	60	827	7.3	.3

Table 3. Outer-Glove Perforations: Primary vs Revision TJA

	Perforations	Total	%	*P*
Surgeon				
Primary TJA	8	219	3.7	
Revision TJA	11	123	8.9	.04
Fellow				
Primary TJA	27	240	11.3	
Revision TJA	22	181	12.2	.77
RNFA				
Primary TJA	6	167	3.6	
Revision TJA	8	132	6.0	.32
Scrub nurse				
Primary TJA	6	315	1.9	
Revision TJA	5	184	2.7	.55
Surgeon/Fellow/RNFA				
Primary TJA	49	626	7.8	
Revision TJA	41	436	9.4	.36

Table 4. Noticed Perforations

Combined	Perforations	Noticed	%
Prep gloves	9	5	55.6
Outer gloves	82	28	34.1
Inner gloves	27	6	22.2
Total	118	39	33.1