At what point during total knee arthroplasty operations are gloves most frequently torn?

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Abstract

Purpose: The aim of this study was to determine the time points during a total knee arthroplasty operation when there is the greatest possibility of tearing a surgical glove and thus the stage of the operation at which there is the greatest risk of infection. Methods: The study included 300 total knee arthroplasty cases performed by 10 orthopedic surgeons. Using a chronometer during the operation, the upper layer of each surgical glove was removed and inflated with sterile saline at 10-min intervals. When a tear was determined, a record was made of the time it occurred, the stage of the operation, the finger that was torn, and the side (right or left hand). Results: The mean time of the glove perforation was 40.74 ± 10.69 min. Glove tears occurred at the rate of 28.9% (n = 39) in the thumb, 63.7% (n = 86) in the index finger, 2.2% (n = 3) in the middle finger, and 5.2% (n = 7) in the ring finger. The tears occurred after the femoral cut in 8.1% (n = 11), after the tibial cut in 14.8% (n = 20), at the stage of trial component reduction in 52.6% of cases (n = 71), after placement of the prosthesis in 7.4% (n = 10), and at the closure stage in 17% (n = 23) (p < 0.001). Conclusion: The fingers requiring the most care during total knee arthroplasty are the thumb and index finger. The stages of the operation with the greatest risk for glove tears are trial component reduction and wound closure. Changing gloves after these high-risk surgical stages would help to decrease the risk of periprosthetic infections.

Level of Evidence: Level IV/Case series

Keywords

infections, periprosthetic joint infection, surgical, surgical gloves, total joint replacement, total knee arthroplasty

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Introduction

The global increase in life expectancy has been accompanied by an increase in the prevalence of diseases such as osteoarthritis. Total knee arthroplasty with a good outcome is seen as a cost-effective surgical procedure1 in patients with end-stage osteoarthritis or secondary degenerative joint diseases associated with rheumatoid arthritis.2 The main complications of total knee arthroplasty are aseptic loosening, instability, and infection. Deep infection is a potential early complication with a high health care cost burden and accounts for 24% of all early revisions.3,4

Infection rates of 0.88–0.92% for primary arthroplasty and 2.9–30.2% for revision arthroplasty have been reported in the literature. Periprosthetic infections are among the most catastrophic complications for both the patient and surgeon. The etiology of periprosthetic infections is multifactorial. The most important factors are diabetes and poor socioeconomic status; however, surgical factors, including operating time and allogeneic blood transfusion, are also important. An increased risk of periprosthetic infection has
been associated with urinary tract infection, myocardial infarction, and a prolonged stay in hospital.\textsuperscript{5}

Glove tears during primary knee arthroplasty are one of the main causes of superficial wound site infection and deep periprosthetic infection.\textsuperscript{6} Perforation of a surgical glove is common in orthopedic surgery. Glove tear rates of 18–73\% per operation have been reported.\textsuperscript{7} Major surgical procedures, such as total knee arthroplasty, are high risk for glove perforation because of bone cutting, use of implant pins in contact with sharp bone edges, and use of osteotomes. Although surgical glove perforation rates during major orthopedic surgery have been reported,\textsuperscript{7,8} there is little information on glove perforation during total knee arthroplasty operations.

The aim of this study was to determine the time during a total knee arthroplasty operation when the risk of a surgical glove tear is highest and thus the stage of the operation when there is the greatest risk of infection.

\textbf{Material and methods}

This prospective study was approved by our institutional review board. The study included 300 primary total knee arthroplasty operations performed between September 2015 and February 2019. Cases were excluded if the reason for surgery was revision knee arthroplasty, if the patellar component was changed, if the operation was bilateral, if the patient had valgus deformity, or if ligament-sparing total knee arthroplasty was performed. The patients comprised 214 (71.3\%) women and 86 (28.7\%) men with a mean age of 67.26 ± 6.45 (range 54–82) years. The operations were performed by any of 10 right-handed orthopedic surgeons using the same surgical procedure. The 300 cases were enrolled by selecting 30 operations performed by each of the 10 orthopedic surgeons. All the surgeons had the same amount of professional experience and all patients received a Genesis II\textsuperscript{®} total knee prosthesis (Smith & Nephew, Watford, UK).

All surgical procedures were performed using powder-free Beybi\textsuperscript{®} double gloves (Istanbul, Turkey). Seven surgeons used no. 8 gloves and three used no. 7 gloves. The mean operating time was 60.85 ± 4.06 (range 55–75) min. Using a chronometer intraoperatively, the outer layer of each surgical glove was removed at 10-min intervals and inflated with sterile saline (Figure 1). When a tear was identified, the time and stage of the operation were recorded along with the finger that was torn and the side (right or left hand). The torn outer glove was then changed and the procedure was repeated every 10 min. When no tear was detected upon inflation with sterile saline, the glove was dried with a sterile sponge and worn again while surgery continued. At the end of the operation, the inner (nonsterile) layer of each glove was removed and inflated with saline to identify any perforations.

\textbf{Surgical procedure}

After administration of cefazoline1000 mg as antibacterial prophylaxis, the patient was placed in the supine position with the necessary draping and staining procedures applied under tourniquet control. An anterior incision was made through the skin and subcutaneous tissue over the patella. The joint was reached via a medial parapatellar arthrotomy. The patella was turned laterally, the tissue with synovitis was cleared, and the meniscus was excised. The femur was cut first, followed by the tibia. Distal femoral cuts were made with intramedullary guide and tibial cut were made with extramedullary guide. Both distal femoral cuts and tibial cuts were made with four pins fixing the guides to the bone. The femoral trial component was applied first and then the tibial trial component; the knee was reduced by placing the trial insert and stability was assessed. The trial components were then removed. After irrigation, the original tibial component was applied first, followed by the femoral component, and then, the insert with cement. A drain was inserted after washing. The fascia, subcutaneous tissue, and skin were then closed and a dressing and an elastic bandage were applied. No local infiltrative analgesia was used.

\textbf{Statistical analysis}

The results are shown as the mean ± standard deviation, median, interquartile range, minimum and maximum, or number and percentage as appropriate. Quantitative data were examined for normality graphically and using the Shapiro–Wilk test. Two or more groups of quantitative data not showing a normal distribution were compared using the Kruskal–Wallis and Dunn–Bonferroni tests. The Fisher–Freeman–Halton exact test was used to compare the qualitative data. All statistical analyses were performed using NCSS 2007 software (Number Cruncher Statistical System, Kaysville, Utah, USA). A $p$-value <0.05 was considered statistically significant.
### Results

The 300 patients who underwent primary total knee arthroplasty in this study comprised 214 (71.3%) women and 86 (28.7%) men with a mean age of 67.26 ± 6.45 (range 54–82) years (Table 1). The mean operating time was 60.85 ± 4.06 (range 55–75) min, and the mean operating time at which tears occurred was 40.74 ± 10.69 (range 20–60) min.

The operations were performed on the right knee in 171 (57%) cases and on the left knee in 129 (43%). There was at least one tear in 113 (37.6%) of the 300 operations. The tear occurred in a single finger in 91 cases (30.3%) and involved two fingers in 22 (7.3%). The tear was in the right glove in 58 (43%) of cases and in the left in 77 (57%). A tear in the inner layer of the glove was identified in four cases (1.3%; Table 2).

Tears occurred at a rate of 28.9% \((n = 39)\) in the thumb, 63.7% \((n = 86)\) in the index finger, 2.2% \((n = 3)\) in the middle finger, and 5.2% \((n = 7)\) in the ring finger (Figure 2). The tears were detected after the femoral cut in 8.1% \((n = 11)\), after the tibial cut in 14.8% \((n = 20)\), at the stage of trial component reduction in 52.6% of cases \((n = 71)\), after placement of the prosthesis in 7.4% \((n = 10)\), and at the closure stage in 17% \((n = 23, p < 0.001;\) Figure 3).

### Discussion

Although the incidence of periprosthetic joint infection is lower than that of aseptic loosening, the former can have more serious complications,\(^9,10\) both diminishing quality of life and increasing the financial burden. Some studies performed in the United States have reported that periprosthetic joint infection is the most common indication for revision knee arthroplasty.\(^11–14\)

Glove perforation is of concern in respect of contamination of the surgical field. Several studies have identified the important factors to be type of surgery, handedness, and operating time.\(^15–18\) However, the present study focused on the time and stage of the operation at which the risk of glove perforation in primary total knee arthroplasty is highest. The main finding was that there was at least one glove tear in 113 (37.6%) of 300 cases. The tears occurred in a single glove finger in 30.3% of cases and two fingers in 7.3%. Although all the surgeons performing the operations were right-handed, 43% of the tears were in the right hand and 57% were in the left hand. This can be explained by the fact that the surgeon holds the instruments in the dominant hand and, with more movement of the other nondominant hand, there is greater contact with sharp surfaces, including bone edges, implants, and tissues. Furthermore, there was

### Table 1. Patient demographic characteristics.

| Variable   | Range | Mean and SD |
|------------|-------|-------------|
| Age (years) | 54–82 | 67.26 ± 6.45 |

| Sex | n | %  |
|-----|---|----|
| Female | 214 | 71.3 |
| Male | 86 | 28.7 |

SD: standard deviation.

### Table 2. Surgical variables.

| Variable                     | Range | Mean and SD |
|------------------------------|-------|-------------|
| Operating time (min)         | 55–75 | 60.85 ± 4.06 |
| Time until glove tear, min \((n = 135)\) | 20–60 | 40.74 ± 10.69 |

| Variable   | n | %  |
|------------|---|----|
| Operated knee |     |    |
| Right | 171 | 57.0 |
| Left | 129 | 43.0 |
| Glove tear |     |    |
| No | 187 | 62.4 |
| Yes | 113 | 37.6 |
| One tear | 91 | 30.3 |
| Two tears | 22 | 7.3 |
| Torn side \((n = 135)\) |     |    |
| Right | 58 | 43.0 |
| Left | 77 | 57.0 |
| Torn glove finger \((n = 135)\) |     |    |
| Thumb | 39 | 28.9 |
| Index finger | 86 | 63.7 |
| Middle finger | 3 | 2.2 |
| Ring finger | 7 | 5.2 |

p Value <0.001

| Stage at which tear occurred \((n = 135)\) | n | %  |
|------------------------------------------|---|----|
| After femoral cut | 11 | 8.1 |
| After tibial cut | 20 | 14.8 |
| Trial component reduction | 71 | 52.6 |
| After placement of prosthesis | 10 | 7.4 |
| Closure | 23 | 17.0 |

p Value <0.001

| Tear in inner layer of glove | n | %  |
|------------------------------|---|----|
| No | 296 | 98.7 |
| Yes | 4 | 1.3 |

SD: standard deviation.
a tear in the inner layer of the glove in 1.3% of cases. With double gloving, the risk of a tear in the outer layer of the glove is high, whereas the risk in the inner layer is greatly reduced.

Glove tears occurred at a rate of 28.9% in the thumb, 63.7% in the index finger, 22.2% in the middle finger, and 5.2% in the ring finger (Figure 2). The risk of a tear was highest in the index finger followed by the thumb, likely because these are the digits that are most active during the operation and are used more often, whereas the middle and ring fingers are used mainly to grip the surgical instruments. No tear was seen in the little finger of any glove in any of the 300 cases, which can be attributed to the little finger being used very little during the surgical procedure.

Several studies related to tears seen in gloves at the end of orthopedic operations have been published. However, these studies have included orthopedic surgical procedures in general and the whole surgical team rather than surgeons performing a specific type of orthopedic operation. In these studies, gloves have been collected at the end of the surgery, inflated with water, and any tears recorded, but none have investigated the operating time until the tear occurred or at what surgical stage the tear developed. The novel feature of this study is that it identified the timing and surgical stage when the risk of a torn glove is highest.

We found that 52.6% of tears occurred in the trial component reduction stage, 17% at the closure stage, 14.8% after the tibial cut, 7.4% after placement of the prosthesis, and 8.1% after the femoral cut. More than half of the tears occurred after reduction of the trial component, which is the stage when the hands are used more often and more forcefully during hammering while placing the components and are in more contact with hard surfaces. The next highest risk of a tear was in the closure stage, which reflects the frequent and repetitive maneuvers with the needle required when suturing the wound. A torn glove was least likely during placement of the prosthesis, probably because surgeons are more careful when placing the original components, avoiding major hand movements to prevent scratches, cracks, or any other damage to the components.

The mean operating time was 60.85 ± 4.06 min and the mean time until a tear occurred was 40.74 ± 10.69 min, ranging from 20 min to 60 min. Most tears occurred after an operating time of 40 min, which coincided with the completion of trial component reduction.

There have been some reports on the rate of glove tears in total knee arthroplasty surgery. These studies have reported the glove tear rates in primary and revision knee arthroplasty and the ensuing infection rates but have not provided information on timing or the surgical stage with the highest risk for tears. The present study, by separating the surgical stages, has obtained valuable information on the surgical stage, the finger involved, and the time of the greatest risk for glove tears.

This study has some limitations. First, all the operations were performed using the same type of surgical glove, and the extent to which this affected our findings is unknown. Second, the gloves were removed at 10-min intervals, inflated with sterile saline, dried, and worn again if not torn; this may have increased the operating time, although by a small amount, as would the extreme care required to avoid infection. Third, only the lead surgeon was included in this study and not the surgical nurse or assistant. However, no periprosthetic infection was seen postoperatively in any patient in this study. Given the possibility of variation in the risk of glove tears according to the surgical technique used, all the operations were performed using the same surgical technique. Furthermore, all the orthopedic surgeons in the study had trained in the same orthopedic clinic, had almost the same level of professional experience, and were right-handed dominant. Therefore, variations in surgical technique could be minimized. Fourth, because if the gloves remained even slightly damp after inflating with saline and drying, they could be more easily torn during the surgical procedure, and so, the rate of glove perforation in this study might be slightly higher than previously reported.

Conclusion

The results of this study demonstrate the importance of wearing double gloves during total knee arthroplasty surgery. Despite tears in the outer glove layer, the rate of tears in the inner layer was very low. The fingers requiring the most care were the index finger and thumb. The stages of total knee arthroplasty with the highest risk for occurrence of glove tears were trial component reduction followed by closure. Changing gloves on completion of these high-risk surgical stages would help to reduce the risk of early periprosthetic infections.

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