



# Surgical Gloves in Orthopedic Trauma Procedures: How Many Lose Their Integrity?\*

## *Luvas cirúrgicas em procedimentos ortopédicos de trauma: Quantas perdem a integridade?*

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### Abstract

**Introduction** The possibility of perforation of gloves during orthopedic surgeries can reach 56.8%, and it mainly related to the manipulation of blunt instruments. Surgeries for the treatment of fractures and trauma present additional risk due to contact with bone spires.

**Objective** Analysis of the prevalence of loss of integrity of surgical gloves in orthopedic trauma procedures, especially fractures, and evaluation of the surgeon's exposure and contact with secretions from the patient.

**Methods** Macroscopic inspection of the gloves of two surgeons specialized in trauma, over a period of 4 months. Both used two gloves for all procedures and, at the end of the surgery, analyzed the presence or absence of blood stains on the internal gloves and/or fingers. The procedures were categorized according to the time and type of surgery. The intercurrent investigated was the perforation of one or two gloves; if the tear was perceived immediately or only at the end of the surgery, and the location of and reason for the tear, if identified.

**Results** A total of 210 surgeries were included, 87 of which presented perforations, with 17 cases occurring in both gloves and 70 only in the outer glove. Finally, there was a more significant relationship with open focus surgeries and duration > 60 minutes.

**Conclusion** Our results suggest that greater care and inspection of gloves to look for damage are needed in prolonged surgeries with an open focus.

### Keywords

- ▶ orthopedic surgeons
- ▶ gloves, surgical
- ▶ protection
- ▶ traumatology

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## Resumo

**Introdução** Cirurgias ortopédicas apresentam a possibilidade de perfuração das luvas, que pode chegar a 56,8%, relacionada principalmente à manipulação de instrumentos cortantes. O tratamento de fraturas e cirurgias de trauma apresenta risco adicional pelo contato com espículas ósseas.

**Objetivo** Análise da prevalência de perda de integridade das luvas cirúrgicas em procedimentos ortopédicos de trauma, principalmente fraturas, avaliando a exposição do cirurgião e o contato com secreções provenientes do paciente.

**Métodos** Inspeção macroscópica das luvas de dois cirurgiões especializados em trauma, durante um período de 4 meses. Ambos usaram duas luvas para todos os procedimentos e, ao término da cirurgia, analisaram a presença ou ausência de manchas de sangue nas luvas internas e/ou nos dedos. Os procedimentos foram categorizados quanto ao tempo e tipo de cirurgia. A intercorrência investigada foi a perfuração de uma ou duas luvas; se a perfuração foi percebida imediatamente ou apenas ao final da cirurgia, e qual o local e o motivo do rasgo, se identificado.

**Resultados** Foram incluídas 210 cirurgias, das quais 87 apresentaram perfurações, sendo 17 casos em ambas as luvas e 70 apenas na luva externa. Um total de 27,5% dos danos foram descobertos apenas no final da cirurgia; os rasgos se concentraram no indicador esquerdo em 62,5% dos casos. Por último, houve uma relação mais significativa com cirurgias de foco aberto e com duração superior a 60 minutos.

**Conclusão** O nosso resultado sugere que em cirurgias prolongadas e com foco aberto, é necessário maior cuidado e inspeção à procura de danos nas luvas.

## Palavras-chave

- cirurgias ortopédicas
- luvas cirúrgicas
- proteção
- traumatologia

## Introduction

Orthopedic surgeries have a greater possibility of perforations in gloves, with handling of blunt and sharp instruments (drills, screws, metal wires, among others),<sup>1</sup> in addition to bone spicules that can injure the surgeon's hand and offer risk of contamination.

Some studies have evaluated the hypothesis of increased infection in procedures in which the surgeon's glove loses integrity, but the results indicated no correlation.<sup>1-4</sup>

The perforation of gloves occurs in 3.5<sup>5</sup> to 56.8%<sup>3</sup> of surgeries; in up to 89% of these, the surgeon may not be aware of the contamination.<sup>6</sup> In addition, perforations are concentrated in the index finger and in the thumb of the non-dominant hand.<sup>1</sup>

Using two gloves decreases the chance of contamination of the surgeon in cases of tears by 87%, and, in the case of perforation of the surgeon's hand with a solid needle, there is a retention of up to 95% of the blood in the gloves, thus minimizing a possible transmission of diseases.<sup>1</sup> The additional pair of gloves decreases the possibility of perforation of the inner glove, reducing the risk of contamination by up to 13 times fold.<sup>7</sup>

There are no studies in the literature that evaluated glove tears only in orthopedic traumatology and fracture correction procedures. Our objective is to evaluate the exposure of the patient and surgeon, determining the prevalence of glove perforations in this type of surgery.

## Materials and Methods

Two orthopedic surgeons with specialization in orthopedic trauma, M. B. and T. G., with 4 and 5 years of training,

respectively, both right-handed, inspected the gloves during and after the surgeries, in the period of 4 months, from July 1, 2019 to October 30, 2019, in the hospitals where they undergo surgical routine (Hospital Santa Cecília, Hospital Santa Maggiore Mooca, Hospital Salvalus and General Hospital of Carapicuíba).

The inclusion criteria were orthopedic trauma surgeries, in which one of the two surgeons involved in this study participated as the main surgeon; procedures for correction and fixation of fractures; removal of synthesis materials (plates or rods); revisions, and pseudarthrosis.

The exclusion criteria were soft-tissue surgeries (tendon or ligament repairs), without the use of orthopedic implants, or removal of percutaneous synthesis materials.

Both surgeons routinely use two pairs of gloves (inner glove and outer glove). All gloves used in the services and hospitals frequented by our team are natural rubber latex, of brands authorized by the quality regulatory body for sterile surgical use.

At the end of the surgery (if there was no perceived perforation throughout the procedure and the change was already made), the outer glove of each hand was removed separately and inspected visually and thoroughly for signs of blood stains in the inner glove (► **Figure 1**). The same procedure was repeated with the internal glove, in search of contamination in the surgeon's hands (► **Figure 1**).

The surgeries were divided into duration greater than or lower than 60 minutes. In addition, we separated them into three groups regarding the type of surgery: percutaneous (such as fixation of distal radius with Kirchner wire); closed-focus surgeries (such as intramedullary tibia or femur stems



**Fig. 1** Internal glove showing loss of integrity of the left index finger perceived at the end of surgery.

with indirect reduction), and open focus surgeries (direct reduction and manipulation of bone fragments, such as forearm or joint fractures)

Regarding the loss of integrity of the gloves, we divided them into two groups: according to perforation and details; these were subdivided as follows:

Regarding perforation, the outcomes may be: Group A: “No tears”: unidentified perforation during the procedure and, at the end, without stains on the internal gloves. Group B “one glove during”: loss of integrity only of the external glove noted during the procedure, but without damage to the inner glove. Group C “two gloves during”: loss of integrity of both gloves perceived during the procedure, with stains on the inner glove and hand of the surgeon. Group D “one glove in the end”: only at the end of the surgery there was staining on the inner glove, and the moment at which the perforation occurred was not identified. Finally, Group E “two gloves in the end”: damage to the internal and external glove, with contamination including the surgeon’s hand, not noticed during the procedure.

Regarding the details, we divided them into finger and side, record as to the region and laterality of the perforations; and moment and mode, if perceived during the procedure and reason for the tear, such as contact with bone spicules, Kirchner wires, during handling of the punch, or when positioning Hohmann-type retractor or reduction calipers.

At the end, a statistical analysis of the variables was performed, using a chi-squared test to compare the various variables found.

**Table 1** Relationship between surgery time and perforations

|                 | Surgical time |              | Total       |
|-----------------|---------------|--------------|-------------|
|                 | < 60 minutes  | > 60 minutes |             |
| Total           | 116           | 94           | 210         |
| Damaged gloves  | 24 (20.6%)    | 63 (67.0%)   | 87 (41.4%)  |
| Integral gloves | 92 (79.3%)    | 31 (32.9%)   | 123 (58.5%) |

## Results

A total of 210 surgical procedures involving internal fixation materials, such as fractures, revisions, removals of material, were evaluated. Regarding time, 116 (55.2%) lasted less than 60 minutes, and 94 (44.7%) more than 60 minutes. Regarding the type of surgery, 20 surgeries were percutaneous, 60 were closed focus, and 130 were open focus. Regarding the loss of integrity, 41.4% of the procedures had perforations or damage to the gloves.

Regarding time, procedures with duration greater than 60 minutes presented a higher rate of tears, with 67%. In surgeries that lasted less than an hour, there was a 20.6% loss of integrity ( $p < 0.001$ ) (► **Table 1**).

Regarding the type of surgery, open focus procedures stood out, with 49.2% of them presenting perforations. On the other hand, 33.3% of closed focus surgeries and 15% of percutaneous surgeries had glove damage ( $p = 0.005$ ) (► **Table 2**).

Regarding the outcomes, considering the 87 surgeries in which there was perforation, the situation of perceiving the tear only in the external glove (group B) during the surgery had a higher rate, with 24.2%. On the other hand, the cases in which there was loss of integrity of two gloves noticed during surgery (group C) accounted for 5.7%. The procedures in which the tear was discovered only at the end of the surgery corresponded to 9% in the external glove only (group D) and 2.3% with perforation of both gloves (group E) (► **Table 3**).

Regarding perception, when there were tears, 63 cases were identified at the time of the surgery. On the other hand, 24 of the perforations were noted only at the end of the surgery during the inspection. In 80% of the cases in which there was a tear, the internal glove remained intact, serving as a barrier to direct contact between patient and surgeon.

**Table 2** Relationship between type of surgery and perforations

|                 | Type of surgery |              |            | Total       |
|-----------------|-----------------|--------------|------------|-------------|
|                 | Percutaneous    | Closed focus | Open focus |             |
| Total           | 20              | 60           | 130        | 210         |
| Damaged gloves  | 3 (15%)         | 20 (33.3%)   | 64 (49.2%) | 87 (41.4%)  |
| Integral gloves | 17 (85%)        | 40 (66.6%)   | 66 (59.7%) | 123 (58.5%) |

**Table 3** Relation to perforation perception

| Perforations - perception |               |              |              |             |
|---------------------------|---------------|--------------|--------------|-------------|
| Group A                   | Group B       | Group C      | Group D      | Group E     |
| 123<br>(58.5%)            | 51<br>(24.2%) | 12<br>(5.7%) | 19<br>(9.0%) | 5<br>(2.3%) |
| Total                     | 87 (41.4%)    |              |              |             |

The site that had the most perforations was the index finger of the non-dominant hand (left), with 62.5% of the cases, followed by the right index finger, with 19.2%, and in third, the left thumb with 9.6% (► **Table 4**).

In cases of loss of integrity in which the reason was identified, the greatest factor responsible was contact with bone spicules, in 45% of cases, followed by perforations with Kirchner wires or guide wires, with 22.5%. Tears during handling of the punch were the causative agent in 12.5%, and the act of positioning a Hohmann-type retractor or reduction clamp in 10% of cases (► **Table 5**).

## Discussion

In the literature, we found different analyses on the subject. Some authors, like Nicolai et al.<sup>8</sup> and Chan et al.,<sup>5</sup> evaluated the gloves of the surgical team, reaching percentages of 14.6% and 3.5%, respectively. Laine and Aarnio<sup>7</sup> and Sanders et al.<sup>2</sup> obtained larger numbers analyzing only surgeons' gloves, with 31.4% and 52% of perforations, respectively. In our study, we found a perforation prevalence of 41.4%.

Surgical time is a factor clearly related to the loss of glove integrity. Louis et al.<sup>9</sup> indicated that 90% of perforations are concentrated in procedures with more than 2 hours. Enz et al.<sup>10</sup> also found more perforations in arthroplasty reviews, which last an average of 116 minutes. Laine and Aarnio<sup>7</sup> indicated a difference of 3.6% of tears in surgeries with less than 1 hour to 14.6% in those of more than 1 hour. Sanders et al.<sup>2</sup> also stated that in the analysis of gloves in procedures with more than 3 hours, 100% presented perforations. Our article indicated a difference of 20.6% of tears in shorter procedures to 67% in long surgeries.

**Table 4** Distribution of the tear site

| Perforations - local (finger) |             |            |             |                  |                    |               | Total |
|-------------------------------|-------------|------------|-------------|------------------|--------------------|---------------|-------|
| Left index                    | Right index | Left thumb | Right thumb | Left ring finger | Left middle finger | Palmar region |       |
| 65 (62.5%)                    | 20 (19.2%)  | 10 (9.6%)  | 4 (3.8%)    | 3 (2.8%)         | 1 (0.9%)           | 1 (0.9%)      | 104   |

**Table 5** Reason for perforations

| Perforations - reason (when) identified |                              |           |   |        |                            | Total |
|---|------------------------------|-----------|---|--------|----------------------------|-------|
| Bone spicules                           | Kirchner wire/<br>guide wire | Punch     | Positioning Hohmann<br>or reduction caliper | Awl    | Palpar screw<br>to fit key |       |
| 18 (45%)                                | 9 (22.5%)                    | 5 (12.5%) | 4 (10%)                                     | 2 (5%) | 2 (5%)                     | 40    |

Although not including only orthopedic trauma procedures in their study, Chan et al.,<sup>5</sup> analyzed their results, also dividing by type of surgery. The result was a higher perforation rate in fixation procedures with intramedullary nail, indicating 33% of perforations, followed by 19% of tears in surgeries with open reduction. Diverging from this information, our work in internal fixations with open focus presented 49.2% of perforations, and in closed focus procedures with intramedullary stems, the result was similar to that of Chan et al.,<sup>5</sup> 33.3%.

Loius et al.<sup>9</sup> and Mafulli et al.<sup>6</sup> had 80% and 89% of the perforations noted only at the end of the surgery; Laine and Aarnio<sup>7</sup> indicated 23% of intraoperative perception when using only one glove and 36% with two gloves. Nicolai et al.<sup>8</sup> presented perception in 10.2% in the group with conventional gloves. Our article obtained an inverse result in relation to these values; we obtained 72.4% intraoperative identification of perforations. In addition, we concluded that the use of double gloves protected the surgeon's hands in 80.4% of the procedures in which there was loss of integrity of the glove, in these cases the inner glove remained undamaged; just as Tanner and Parkinson's<sup>1</sup> indicated as a protective factor.

Regarding the location of the perforations, Nicolai et al.<sup>8</sup> and Laine and Aarnio<sup>7</sup> indicated the occurrence of 73.6 and 70% of tears in the non-dominant hand; our analysis found a similar value, with 76.6%. Lee et al.<sup>11</sup> found a higher prevalence distribution of holes in the non-dominant index, followed by the dominant index finger and the non-dominant thumb, which agreed with our results. Our article identified 62.5% of the tears located in the index finger of the left hand, 19.2% in the right index finger, and 9.6% in the left thumb.

As a limitation of the present work, the method of detecting the loss of integrity differs from that recognized and standardized in the United States and in Europe (The American Society for Testing and Materials and The European Standards Committee), which consists in filling the glove with 1,000 ml of water and suspending it with a clamp by the collar, thus allowing water to flow through possible perforations. Another option found in the literature is to fill the glove with 500 ml of water and squeeze it to evaluate water leakage.<sup>12</sup> Another limitation was the non-detailing of the population or type of surgery.

## Conclusion

Our study indicated 67% of perforations in longer surgeries against 20.6% in surgeries with duration of less than 1 hour. Open reduction surgeries showed loss of integrity in 49.2% of cases, closed reduction surgeries, in 33.3%, while percutaneous surgeries only showed loss of integrity in 15% of cases. The most affected finger was the index of the non-dominant hand, responsible for 62.5% of the perforations. In addition, in 72.4% of the times, the tear was perceived throughout the surgery, and the most frequent reason was contact with bone spiculae.

### Conflict of Interests

The authors declare that there is no conflict of interests.

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