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GLOVE DAMAGE IN TOTAL HIP ARTHROPLASTY

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Background. Glove damage during orthopedic operation can reach an incidence of 26.1%, whereas perforations in gloves go unnoticed by surgical team members in most cases (up to 82%), which certainly increases the risk of wound contamination and hemocontact infection transmission.
Aim. The aim of this study was to assess the frequency of glove damage among hip arthroplasty surgical team members, to identify the nature, location, and risk factors of damage to surgical gloves.
Materials and methods. A total of 1418 surgical gloves (709 pairs) that were used by surgeons, assistants, and surgical nurses during 154 primary and revision total hip arthroplasty (THA) were included in the analysis in this study.
Results. Damage to surgical gloves was observed in 69 (44.8%) operations: 54 operations of the primary THA (42.2%) and 15 revision THA (57.7%). Of 1418 gloves used, 95 were damaged (6.7%); 68 of 1166 gloves (5.8%) were damaged during primary hip arthroplasty and 27 of 252 gloves (10.7%) were damaged during revision THA. During primary and revision arthroplasties, glove perforations were observed in most cases: 83.6% and 85.7%, respectively. Most of the cases of glove damage were found in surgeons (45.2% of cases), and 41.1% and 13.7% of the cases of glove damage were experience by assistants and operating room nurses, respectively. The most frequent location of damage in the gloves was on the second finger of both hands: on the left, 40.3%, and on the right, 33.3%. Gloves were damaged in 42.1% of cases in primary arthroplasties lasting up to 70 min and in 42.3% of cases in those lasting more than 70 min. In revision hip arthroplasties lasting up to 95 min, gloves were damaged in 38.5%, and in revisions that lasted more than 95 min, in 76.9% cases.
Discussion. Glove damage during revision THA most often occurs to the surgeon suturing the wound (87.4%) and usually remains unnoticed. Risk factors for glove damage are the length of the operations and the use of sharp tools, knitting needles, and wire.
Conclusion. Use of apodactyl operational techniques and periodic change of surgical gloves can reduce the risk of damage to gloves and, as a result, reduce wound contamination and the transmission of blood-borne infections.

Keywords: surgical gloves; perforation; rupture; hip arthroplasty.

ПОВРЕЖДЕНИЕ ХИРУРГИЧЕСКИХ ПЕРЧАТОК ПРИ ЭНДОПРОТЕЗИРОВАНИИ ТАЗОБЕДРЕННОГО СУСТАВА

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Обоснование. Частота повреждения хирургических перчаток во время ортопедических операций может достигать 26,1 %, при этом в большинстве случаев (до 82 %) перфорация перчаток остается незамеченной, что, безусловно, повышает риск контаминации раны и передачи гемоконтактных инфекций.
Цель — оценить частоту повреждений перчаток у членов хирургической бригады при эндопротезировании тазобедренного сустава, выявить характер, локализацию и факторы риска повреждений хирургических перчаток.
Материалы и методы. Материалом для исследования послужили 1418 хирургических перчаток (709 пар), использованных хирургами, ассистентами и операционными сестрами в ходе 154 операций первичного и ревизионного эндопротезирования тазобедренного сустава.

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Результаты. Повреждение хирургических перчаток отмечено в ходе 69 операций (44,8 %): 54 операции первичного эндопротезирования (42,2 %) и 15 ревизионного эндопротезирования (57,7 %). Всего было повреждено 95 из 1418 перчаток (6,7 %), при первичном эндопротезировании повреждено 68 из 1166 перчаток (5,8 %), при ревизионном — 27 из 252 (10,7 %). При первичном и ревизионном протезировании в большинстве случаев наблюдалась перфорация перчаток — 83,6 и 85,7 % соответственно. Большинство случаев повреждения перчаток выявлено у хирургов — в 45,2 % случаев, у ассистентов — в 41,1 % и у операционных сестер — в 13,7 %. Наиболее повреждаемые участки перчаток были локализованы в области II пальца обеих рук: слева — в 40,3 %, справа — в 33,3 %. При первичном эндопротезировании продолжительностью до 70 мин перчатки были повреждены в 42,1 % случаев, а при продолжительности более 70 мин — в 42,3 %. При ревизионном протезировании тазобедренного сустава продолжительностью до 95 мин перчатки были повреждены в 38,5 %, а при ревизиях, длившихся более 95 мин, — в 76,9 % случаев.

Обсуждение. Наиболее часто повреждение перчаток происходит при ревизионном протезировании у хирурга, ушивающего рану, и в большинстве случаев (87,4 %) остается незамеченным. Факторами риска повреждения перчаток являются продолжительность операции и использование острых инструментов, спиц, проволоки.

Заключение. Снизить риск повреждения перчаток и, как следствие, контаминации раны и передачи гемоконтактных инфекций позволит применение максимально аподактильной оперативной техники, а также периодическая смена хирургических перчаток.

Ключевые слова: хирургические перчатки; перфорация; разрыв; эндопротезирование тазобедренного сустава.

Background

Total arthroplasty (AP) is considered to be the most effective treatment method of hip joint (HJ) pathology [1]. This is largely due to a steady increase in the number of surgical interventions performed worldwide. However, some patients who have undergone primary HJ AP need to undergo revision surgery in the first year due to various complications [2]. The third most common reason for surgical revision is the occurrence of infectious complications, and the number of required interventions during the first postoperative year approaches 3% [3]. Moreover, surgical site infections are a leading cause of early revisions during the first year after joint replacement [4]. More importantly, damage to surgical gloves may be considered one of the main risk factors of surgical wound contamination by pathogenic microorganisms and subsequent development of periprosthetic infection [5]. In addition, the use of surgical gloves, together with compliance to aseptic and antiseptic procedures, serve to maintain a protective biological barrier between the hands of the surgical team members and the patient, thereby helping reduce the risk of transmission of blood-borne infections such as HIV, viral hepatitis, etc. [6, 7].

The average frequency of perforations of gloves during surgical interventions approaches 35% [8], while the risk of damage to surgical gloves exists even when performing minor surgical procedures on soft tissues [9].

Obviously, surgical gloves must meet the needs of surgeons, taking into account the specifics of surgical interventions, their duration, as well as the individual tolerance of the various materials used to manufacture the gloves [10].

Most surgical gloves are currently made of synthetic materials such as vinyl, nitrile, neoprene, and polyurethane. Such products are less likely to cause allergic reactions, are pliable and durable, as well as resistant to damage and chemicals. The main disadvantage of synthetic gloves consists of their higher cost compared to products made from natural latex [11]. Some economically-minded researchers have proposed reusing sterilized gloves [12]. However, due to the relatively high frequency of intraoperative perforations, repeated use of gloves appears to be impractical. Alternatively, other authors have suggested using two pairs of surgical gloves when performing orthopedic surgeries to reduce the risk of perforation and subsequent contaminations [13, 14]. Nevertheless, even with primary HJ AP, the frequency of damage to the inner pair of gloves may reach 4.3%, and even more with revision interventions [15]; therefore, a number of researchers have recommend replacing surgical gloves periodically during HJ AP [16].

When examining the available literature on damage to surgical gloves, it appears that a lot of studies have been performed in this field, but that, in Russia, no published data are available regarding this important problem in orthopedics. Hence, in the present study, we set ourselves the task to establish

the frequency of damage to the surgical gloves of surgical team members during primary and revision arthroplasty (ReAP) of the HJ. Our goals were to determine the nature and sites of surgical glove damage, and furthermore, to identify the important risk factors for damage to surgical gloves.

Materials and methods

In the course of the study, 1,418 surgical gloves (i.e., 709 pairs) made of natural latex and synthetic rubbers were analyzed, while they were being used by surgeons, assistants, and surgical nurses during 154 hip arthroplasty interventions; 1,166 gloves (82.2%) were used for primary AP (128 surgeries, 83.1%); and 252 gloves (17.8%) were used with ReAP of the HJ (26 surgeries, 16.9%). Surgeons and surgical nurses used 616 of the gloves (308 pairs), while assistants used 778 gloves (389 pairs). In 12 cases, involving 24 gloves, gloves were changed after being damaged. Of these 12 cases, eight involved a surgeon, three a surgical assistant, and one involved a surgical nurse.

The average duration of primary HJ for AP was 74.1 min (95% CI 70.0–78.1; median 70 min) and ReAP lasted for 103.1 min (95% CI 84.9–121.2; median 95 min).

After each surgery, surgical gloves were examined for perforations and ruptures according to a previously described standard method [17]. Briefly, the gloves were filled with one liter of water at room temperature, and checked for defects for two min by manually pressing each finger and the interdigital spaces of the glove (Fig. 1).

The data from surgical reports and results of testing surgical gloves for damage were transferred to a special questionnaire for further statistical analysis using SPSS software (Version 24.0). In addition to average values, the median and interquartile range were determined. The outcomes were compared using χ^2 tests and relative risks were calculated as well.

Results

The average duration of all surgical interventions was 79.0 min (Me 70 min; IQR 60–90). Primary AP interventions were performed faster, with an average duration of 74.1 min (Me 70 min; IQR 60–80), while revision AP took, on average, 103.1 min (Me 95 min; IQR 60–132.5).

Fig. 1. Method of investigation of damage to surgical gloves

Each surgical team involved 4–6 members, namely, a surgeon, a surgical nurse, and two to four assistants. Specifically, primary AP was performed by a five-member team in 46.1% of cases, and revision surgeries in 69.2% of cases. All cases of primary and revision arthroplasty involved four assistants who prepared grafting material to repair bone defects in patients. During 50 (i.e., 32.5%) of the surgical interventions, the surgeon sutured the wound, whereas in 104 cases (67.6%), an assistant performed this task.

Damage to surgical gloves of various degrees occurred during 69 surgical interventions (44.8%), of which 54 (42.2%) occurred during primary AP interventions and 15 (57.7%) during ReAP; however, these differences were not statistically significant ($p < 0.15$). In total, 95 out of 1,418 used gloves (i.e., 6.7%) were damaged during surgery including primary AP, 68 of 1,166 gloves (5.8%) during primary AP, and 27 out of 252 gloves (10.7%) during. The relative risk of perforation or other damage to the gloves during the repeat HJ AP compared to the primary operation was 1.837 (95% CI 1.202–2.809; $p = 0.005$). Damage to two or more gloves during a single operation was detected in 12 of 54 primary AP (22.2%) and in six out of 15 ReAP operations (40%; $p < 0.17$).

A total of 101 damaged areas on 95 gloves were analyzed. In 12 of these (12.6%), damage was detected during the surgery and gloves were changed, while in the remaining 83 cases (87.4%),

Table 1

Comparative characteristics of the groups of primary and revision hip arthroplasty

Indicators	Primary AP	Revision AP	Total
Number/percentage of surgical interventions, % (*n*)	83.1 (128)	16.9 (26)	100 (154)
Average duration of surgery, min	74		
Glove damage occurrences, % (*n*)	35 (54)	9.8 (15)	44.8 (69)
Perforation rate, % (*n*)	83.6 (56)	85.7 (24)	80
Rupture rate, % (*n*)	16.4 (11)	14.3 (4)	15

Note. AP — arthroplasty.

the damage was registered after the operation. 80 of these cases (84.2%) involved perforation, 14 cases (14.8%) involved rupture, and combined perforation and rupture was seen in one case (1.1%). In primary AP, 83.6% of the damage cases consisted of perforation (56 gloves) and the remaining 16.4% of cases involved rupture (11 gloves). With ReAP, the perforation frequency was 85.7% (24 gloves) and the rupture rate was 14.3% (4 gloves) (Table 1).

45.2% (I.e., 43) of all detected cases of damage involved the surgeon's gloves. Of these, perforation was detected in 39 (i.e., 90.7%) and rupture was detected in four (i.e., 9.3%). In 41.1% (39) of incidents, damage occurred with the gloves of an assistant. Similar to the pattern with the gloves of surgeons, perforations occurred more often (79.5%; 31 gloves) than ruptures (20.5%; 8 gloves). 13.7% (i.e., 13) of all cases of damage were seen in gloves of the surgical nurses, with 10 cases of perforation (76.9%) and three (i.e., 23.1%) concerning rupture (Fig. 2).

Thus, in nearly half of all incidents, the surgeon damaged the gloves, most often by perforation, which is likely to result from the frequent manual handling of sharp instruments and contact with sharp edges of bone fragments. Among surgical nurses, compared with other members of the surgical team, glove ruptures predominate, which probably occurs during their handling of heavy and sharp surgical instruments during operations and during clearing of blood and wound-related debris.

Of the 50 surgical interventions during which the surgeon independently sutured the wound, 15 (i.e., 30%) involved damage to surgical gloves with perforation in 13 cases (86.7%) and rupture in two cases (i.e., 13.3%). Of the 104 surgeries involving wound suturing by an assistant, 24 (i.e., 23%) were accompanied by glove damage, with 18 cases (75%) of perforation and 6 cases (25%) of rupture.

This implies that the surgeon who sutured the wound had a higher frequency of damage to the gloves than the assistants who sutured the wound; however, it is also possible that damage to the surgical gloves occurred in previous stages of the intervention.

Assessment of the most frequently damaged areas of surgical gloves showed that damage to

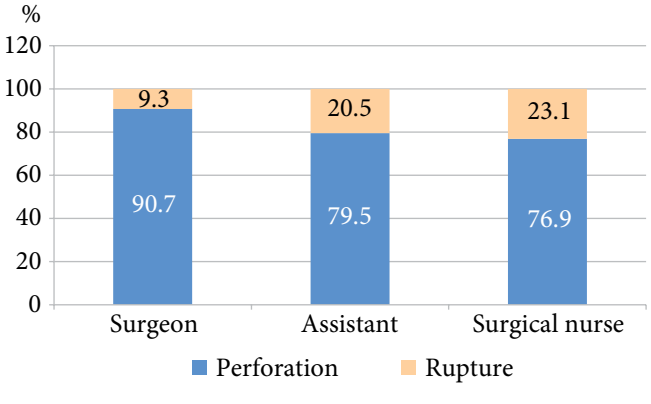

Fig. 2. Distribution of options of damage to gloves of the surgical team members

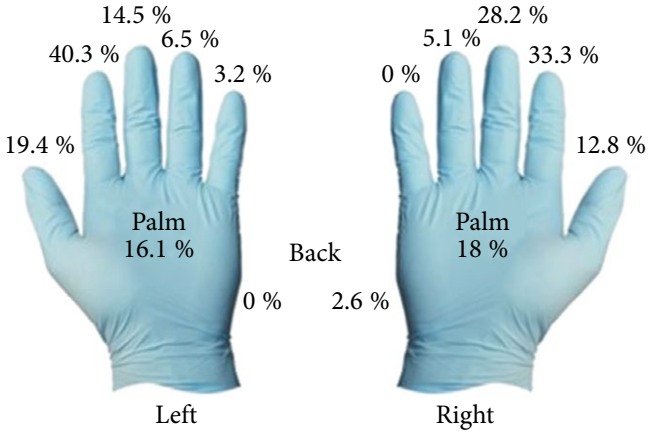

Fig. 3. Distribution of the frequency of damage to surgical gloves, depending on localization

fingers I, II, and III of both gloves occurred in 74.25% of cases, with 37.6% of the damage occurring to finger II. A detailed study showed that, on the right hand, fingers II and III were most often damaged (33.3 and 28.2%, respectively). In contrast, the vast majority (40.3%) of damage on the left hand occurs to finger II (40.3%) (Fig. 3).

In 12 cases, members of the surgical team noticed damage to the surgical gloves during surgery, with 10 observations made during primary AP and two during revision interventions. In all these cases, the damaged surgical gloves were replaced. Elicitors of glove damage included surgical instruments (accounting for 5 cases), pins, screws, wire and needles (5 cases), and sharp bony edges (2 cases).

In the present study, we also tried to elucidate whether the frequency of glove damage was related to the duration of surgical intervention. The median duration of the surgical intervention was taken as reference. During initial HJ AP interventions lasting 70 min or less, gloves were damaged in 32 out of 76 surgical interventions (42.1%), with 4.8% damaged gloves (38 gloves out of 335 glove pairs used). Among HJ AP interventions lasting more than 70 min, glove damage occurred in 22 out of 52 (42.3%) cases, with 30 total damaged gloves out of the 238 pairs used (6.3%). Among repeated HJ AP interventions that lasted up to 95 min, glove damage was seen in 5 of 13 surgeries (38.5%) (8 cases per 61 pairs; 6.5%). In turn, during revisions lasting over 95 min, gloves were damaged in 10 out of 13 surgical interventions (76.9%). Damage was detected in 19 cases of 63 pairs of surgical gloves used, which amounted to 15.1% ($\chi^2 = 3.939$; $p = 0.048$). Thus, revision interventions lasting more than 95 min can be considered as posing a risk factor for glove damage. The relative risk of damage to the gloves with a revision duration of more than 95 min was 2.0 (95% CI 0.945–4.231).

Discussion

According to the literature, the frequency of damage to surgical gloves during orthopedic surgical interventions varies widely (from 3.6 to 26.1%) [18–21] and depends on the type of gloves and the procedures performed [21, 22]. In particular, Kumar et al. reported that with primary HJ AP, the frequency of glove damage was 5.24%, and with ReAP it was almost twice as high (9.65%) [15]. Nilsolaf Hübner et al. showed that, with some surgical manipulations, the difference in the frequency of damage can fluctuate more than twice, from 6.6 to 13.9%, depending on the model of gloves used [22]. More importantly, as J.C. Harnoss et al. noted in their study, in the vast majority of cases (82%), perforations in surgical gloves remain unnoticed by the surgical team [8].

In our study, the frequency of glove damage amounted to 6.7%; the damage occurred more often with ReAP, in 10.7% cases, compared with 5.8% with primary AP, figures that are consistent with the existing literature. However, another more important conclusion from our study should be that, in spite of the perhaps small proportion of gloves damaged overall, adverse events occurred in 42.2% of the primary, and 57.7% of the revision interventions, that is, in almost half of all surgeries. Even more seriously, in 87.4% of cases, these events remained unnoticed. This underscores the importance of periodic changes of surgical gloves during interventions (every 60–90 min). At the International Consensus Meeting on Musculoskeletal Infection, this notion was put forward as a strict recommendation, albeit still based on a limited body of empirical evidence [23]. The vast majority of authors agreed that the duration of use of surgical gloves during prosthetics is correlated with the risks of contamination [24] and damage [6]. Moreover, Selma Sayın et al. specified a direct relationship between the frequency of glove perforations and the duration of surgery [25]. In our study, such dependence was found only for revision surgeries; it is possible that additional, as yet undescribed, factors play a role in the primary AP.

Among the analyzed, damaged gloves, damage was most often noted on finger II of the left hand (40.3%), which is in line with reports by other researchers. In particular, J.C. Harnoss et al. noted, as far back as 2010, that 86% of perforations occur in the non-dominant hand, and that the area of the index finger (36%) is most often damaged [8], which is probably related to the need for manual control of surgical procedures during joint replacement.

During orthopedic surgical interventions, including HJ AP, the use of sharp and piercing instruments, such as needles, awls, screws, cerclage, power equipment [26, 27], as well as the presence of sharp bone protrusions, increases the risk of surgical glove perforation [21, 28] and consequent wound

contamination and transmission of blood-borne infections [29–31]. In our study, wire for additional locking of bone fragments was used in three revision operations and in one case of primary AP. In all four cases, glove damage occurred, which implicates the use of wire as a factor of extreme risk of damage to surgical gloves.

In the present study, we did not find any correlation between glove damage and the development of infectious complications in any of the may over the first three postoperative months. Moreover, there were no complaints that raised suspicion of infectious process development. However, with longer follow-up periods, an adverse effect of these damages might actually be detected. Also, in our study, no further adverse events occurred in the form of infection of surgical team members with blood-borne infections. Nevertheless, an increased risk of such events should not be excluded and warrants further follow-up.

Conclusion

Compromised integrity of surgical gloves, which can lead to wound contamination, is unfortunately a frequent occurrence in both primary and revision hip arthroplasty. The fact that in the vast majority of cases, the members of the surgical team do not tend to notice the perforation of the gloves increases the importance of using the most apodactylic technique possible when performing surgical interventions. It furthermore seems advisable and necessary to change surgical gloves periodically during prolonged contact with surgical wounds, especially bone fragments. Finally, it should be realized that use of sharp retaining elements — wire or pins — presents an additional risk factor for glove damage.

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Contribution of the authors

A.A. Boyarov acquired the data, analyzed the study results, and wrote the publication.

R.M. Tikhilov edited the manuscript.

I.I. Shubnyakov analyzed the research results and edited the manuscript.

A.I. Midaev acquired the data and prepared the manuscript for publication.

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