

SURGICAL GLOVES DAMAGING DUE TO VARIOUS FACTORS DURING FOOT AND HAND ORTHOPEDIC PLATING PROCEDURES

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ABSTRACT

Introduction: The operation teams are exposed to infectious and pathogenic agents during surgical procedures. Surgical gloves, as aseptic tools, prevent cutaneous bacterial infections from being transferred from the personnel to the surgery environment. This issue is highly important in orthopedic operations due to the presence of sharp and cutting instruments.

The present study has been performed with the objective of investigating the extent to which the surgical gloves are damaged by various factors during plating operations or foot and hand orthopedic surgeries.

Method: in the present descriptive-analytical study, 384 surgical gloves (192 pairs) were selected as the study sample volume. The gloves were all made of the same material and they were consisted of two layers. The gloves were selected based on a simple sampling study method. The study environment was the orthopedic and nerves operating room in Ayatollah Kashani Hospital associated with Isfahan's Medical Sciences University. The study population included the gloves wore by the scrubbed individuals during foot and hand orthopedic plating operations. Data collection tools were comprised of questionnaires and checklists all constructed by the researcher. Questionnaire contained demographic information, surgery type and the operation team members and the checklists covered items pertaining to the surgical gloves damages. The present study made use of water-leak test to evaluate whether the gloves have been damaged or not. To analyze the data, descriptive statistics tests and analytical statistical tests were applied and the data were further inspected in the SPSS software, ver. 22.

Results: the damage rate in hand plating surgeries was equal to 18.8% (36.192) and it was found equal to 37.9% (67.192) for foot plating operations. As it is seen the damage rates are significantly higher in foot plating surgeries ($P < 0.05$). In hand plating operations, the greatest number of the obvious damages was seen in a time span from 30 min to 60 min; additionally, the greatest number of the damages was seen in a time span from 60 min to 90 min during foot plating surgeries. Among the gloves used by the operation team members, the assistant surgeons' gloves were found most frequently damaged and the great majority of the damages belonged to the thumb and forefinger regions. The damage rate was predominantly lower in the interior layer of the gloves respectively to the outer layer.

Discussion and Conclusion: Wearing bi-layer gloves can cause a reduction in the damage to the interior layers and therefore lowers the risk of needle sticking injuries and transfer of infection between the operation team members. According to the results, operation team members, especially the surgeons and their assistants, are suggested to preferentially check their gloves for any damage in their dominant hands and their forefingers as well as their thumbs and palms so as to mitigate the infection transfer rate. Also, based on the results, it is suggested that the gloves should be routinely replaced in hand plating operations after 60 minutes and after 90 minutes in foot plating operations.

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Introduction

Infections transferred during surgeries from the patient to the surgeons can be considered as occupational injuries. Operating room surgeons and personnel are in a high risk of being exposed to patients' blood and body liquids. Surgical gloves have been increasingly advanced to protect the individuals' hands against infections transferrable from the patients. In other words, preventing the infections from transferring to the operation team has increased in its significance. Specific conditions of every surgery and longer periods of contact to blood mean higher risks of blood pathogens' transfer [1]. Thus, being exposed to the blood pathogens by the personnel is regarded as one of the serious dangers that should be placed atop of the prevention priority lists [2]. Although healthy skin acts as a good barrier to the infiltration of pathogenic agents the existence of a small microscopic scratch on the skin surface can act as a deep groove through which the microorganisms can penetrate which can cause the emergence of skin-related infections or systemic ailments [3]. There are high concerns for the transferring of infections between the operation team and patients [4] and there is also the risk of infectious pathogens transfer between the two foresaid groups and such a risk can be decreased by means of barriers and protectors [5]. Surgical gloves prevent the operation team members' hands from getting in touch with the patients' blood and they act as protective barriers against the blood pathogens such as AIDS, Hepatitis B and hepatitis C [6]. Furthermore, surgical gloves are good protective barriers saving the healthcare personnel and patients against infectious secretions during emergency operations [7]. Statistics indicate that the risk of being infected with viruses as a result of needle sticking injuries for AIDS, Hepatitis B and Hepatitis C are 0.3%, from 6% to 37% and 1% to 2%, respectively [8].

Studies show that the frequent use of the puncturing instruments during orthopedic surgeries such as nails, wires, saws or needles increases the transferring risk of infections such as HIV, HBV and HCV [9]. In addition, the operation team members are also exposed to the risk of gloves damaging during the surgeries and it seems that the surgeons are inter alia subjected to the highest risk of such dangers as a result of frequent manual activities and repetitive application of sharp tools during surgeries [10].

There are numerous contributing and risk factors associated with the surgical gloves damaging among which the roles of time, individuals during operations, the use of one-layer or two-layer surgical gloves, the type of the operation, namely emergency or elective, can be pointed out [8&6].

The results of the studies performed by Choudhari and Padia demonstrated that the total rate of the surgical gloves damaging is 9.4%, with the highest rate, 45%, going to the gloves used by the surgeons and the lowest rate, 4.5%, being calculated for the scrubbing individuals. Gloves' damage rate 100 minutes after the onset of the operation was found 67% and a rate equal to 30.4% was obtained before 100 minutes of the onset of the operation. The highest rate of damage was found belonging to the forefinger and the dominant hand in the current research paper [8].

The results obtained by D'souza et al indicated that the damage rates for groups of surgeons, assistant surgeon and nurses who had used single surgical gloves were 25%, 11% and 10%, respectively and they have been computed 1.58%, 4% and 2.72%, respectively, for the groups that had used two pairs of gloves. Additionally, the damage rate was found 46.66% in surgeries that lasted more than 90 minutes and a rate of 18.94% was figured out in operations that finished in a period below 90 minutes [6].

The results of the studies carried out by Kaya et al, in 2011, showed that 32 gloves were found damaged during 19 surgeries. Among the damaged gloves, 28 ones were belonged to the surgeons and assistant surgeons. In the present study, 81.3% of the damages were seen in the thumb and forefinger areas. There was no significant difference found between the two groups, joint replacement and reconstruction operations, regarding the time of making use of the gloves, the number of the damaged gloves and the surgery duration [11].

Prior research is reflective of the triviality of the studies regarding the orthopedic plating operations. Also, the results obtained for the extent to which the gloves are damaged in various kinds of surgical operations [12] and their classification based on variegated risk factors are complying in some cases and incompliant in others [6, 13-14 and 15]. Some of these risk factors encompass the types of the material used in gloves, the inner and outer layers of the gloves, surgical procedure type, and operation time, the role of the individuals in surgeries and individuals' dominant hands. Having a clear understanding of the various risk factors can be considerably helpful in lowering the risk of gloves' damaging and the reduction in the infections' transfer between the operation team members and patients. The present study aims at the survey of the rate to which the surgical gloves are damaged due to various factors during the hand and foot plating orthopedic surgeries.

Study Method

The current research paper has been carried out based on a descriptive-analytical method in 2016 in an orthopedics and nerves operating room in Ayatollah Kashani Hospital associated with Isfahan's Medical Sciences and Treatment Services University. The study sample volume included 384 gloves that had been worn by the scrubbed individuals present in hand and foot plating operations. Out of the 384 gloves, 192 ones were used in hand plating and 192 ones were used in foot plating operations. In each of these two sets of surgeries, 64 gloves belonged to the surgeons, 64 ones to the assistant surgeons and 64 others were from the scrubbed individuals. A total of 12 samples were taken from each surgery out of which four belonged to the surgeons, four to the assistant surgeons and four to the scrubbed individuals. The four samples belonging to each of the individuals included the inner right gloves, the inner left gloves, the outer right and the outer left gloves. The entire gloves were made of two layers and all had the same material. After each one of the gloves were taken off, the reason and the time of the gloves'

removal were recorded. However, only the outer layer of the gloves was replaced during the operation and the new gloves were not taken into consideration for further investigation. Data collection tool was comprised of researcher-made questionnaire and checklist.

Questionnaire included the demographic information pertaining to the surgery as well as to the operation team members and the checklist embraced items pertaining to the surgical gloves damages. The questionnaire contained items regarding the type of the surgery, the number of the scrubbed individuals present during the operation, dominant hand, gender and the individuals' work history. Checklist contained items pertaining to the gloves' damages including the roles of the individuals present during the operation, gloves hand orientation (left or right), the gloves being used interiorly or exteriorly and their sizes; also, including the shape, position, the number of the damaged points on the gloves and the time the damage had occurred.

The gloves were labeled after being discarded by the individuals and they were transferred to outside the operating room for the purpose of undergoing water leak test which is a standard method for analyzing the surgical gloves around the globe [10]. The study inclusion scales were the shortness of the operation team members' nails, the presence of the operation team members from the very beginning, the elective nature of the surgeries, not manually working with tools damaging the gloves and use of identical materials in the entire gloves. Study exclusion scales were the illegibility of the gloves' labels, the imperfect preparation of the data pertaining to each of the gloves and conducting processes other than what had been specified for the main intervention that was to be carried out on the patient during the surgery.

To analyze the data, the following statistical tests were undertaken: Pierson's chi-square test, Fisher's exact test and t-tests for two independent samples and the data were analyzed by means of SPSS software, version 22.

Results

The study sample volume selected in the current descriptive-analytical research was comprised of 384 surgical gloves used in 32 orthopedic surgeries and donned by scrubbed operation team members such as surgeons, first assistant surgeons and scrubbed individuals and they entered the study according to the study inclusion criteria. The samples were investigated for the damage rate due to various factors during hand and foot plating operations performed in Isfahan's Ayatollah Kashani Treatment and Educational Center in 2016. From the 384 studied gloves, 192 gloves (50%) were from the hand plating operations (16 surgeries) and 192 others (50%) were belonged to foot plating operation (16 surgical operations). The mean number of the scrubbed individuals in the entire 32 hand and foot orthopedic surgeries was 3.66 ± 0.139 , with the mean number of the scrubbed individuals in the 16 foot plating operation was 3.94 ± 0.123 and it has been 3.35 ± 0.155 in the entire hand plating operations. The results pertaining to the frequency distribution of the surgical team scrubbed individuals and their work histories and genders are given in (table 1).

Table 1. Frequency distribution of the demographic characteristics pertaining to the orthopedic surgery team members

		SEX		Total
		N (%)		
		Male	Female	
Role	SURGEON	32	0	32
		100.0%	0.0%	100.0%
	ASIST	32	0	32
		100.0%	0.0%	100.0%
	SCRUB	11	21	32
		34.4%	65.6%	100.0%
Total		75	21	96
		78.1%	21.9%	100.0%
		Role	Mena	Std. error of mean
		Surgeon (n=32)	6.38	1.22
Work history		Assist (n=32)	2.28	0.144
		Scrub (n=32)	12.53	2.14

The results pertaining to the damage frequency distribution of the surgical gloves used in the hand and foot orthopedic surgeries are presented in [table 2]. Chi-square tests were suggestive of a significant difference in terms of the frequency of the damages and the type of the surgery (P-value = $0.001 < 0.05$); it means that gloves' damaging in hand plating operations was indicative of a frequency percentage equal to 34.9 which is higher than the frequency percentage obtained for hand plating surgeries, 18.8.

Table 2. Frequency distribution of the gloves damaged during the hand and foot plating operations

		Damage		Total	P-value
		No	Yes		
Surgery	Foot Surgery	125 65.1%	67 34.9%	192 100.0%	0.001*
	Hand Surgery	156 81.2%	36 18.8%	192 100.0%	
Total		281 73.2%	103 26.8%	384 100.0%	

(* a significance level below 0.05 has been considered for P-Pierson's chi square test)

Hand Plating Surgeries

According to [table 3], it can be seen that, in 5% significance level, the frequency percentage of the gloves damaging in the scrubbed individuals (8.3%) is significantly (*P<0.05) lower than what was found for assistant surgeons (47.2%) and surgeons (44.4%). As for the hand orientation of the gloves, it was observed that the frequency of the damage appearance did not show any significant difference in both hand orientations (P>0.05). However, it was found out that the damage frequency has been higher in right hand glove (61.1%) as compared to the left hand glove (38.9%).

From the total 36 damaged gloves, 28 gloves were belonged to the dominant hand and 8 gloves belonged to the non-dominant hand. Based on this, the frequency of the damage emergence was found higher in the gloves pertaining to the dominant hand as compared to the non-dominant hand. The results of the damage frequency distribution for dominant hand gloves are summarized in (table 4).

Table 3. Frequency distribution of the gloves damaged in hand plating surgeries based on the gloves' role and orientation

		ROLE			Total	P-value
		SURGEON	ASIST	SCRUB		
Damaged gloves	No	48 30.8%	47 30.1%	61 39.1%	156 100.0%	0.002*
	Yes	16 44.4%	17 47.2%	3 8.3%	36 100.0%	
Total		64 33.3%	64 33.3%	64 33.3%	192 100.0%	
		SIDE		Total	P-value	
		RIGHT	LEFT			
Damaged gloves	No	74 47.4%	82 52.6%	156 100.0%	0.139	
	Yes	22 61.1%	14 38.9%	36 100.0%		
Total		96 50.0%	96 50.0%	192 100.0%		

(* a significance level below 0.05 has been considered for P-Pierson's chi square test and Fisher's exact test)

Table 4. Frequency distribution of the damages based on dominant hand in hand plating operations

	Dominant	Not dominant	Total	p-value
Damaged gloves	28	8	36	0.003*
	77.8%	22.2%	100%	

(* a significance level below 0.05 has been considered for P-Pierson's chi square test and Fisher's exact test)

Corresponding to [table 5], it was observed that the damage frequency in the form of puncturing was identical to the damage frequency that was appeared in the form of rupture in all of the 36 damaged gloves. The frequency of the damage emergence in the outer layer of the gloves (69.4%) was significantly (P-value = 0.010 < 0.05) higher than the inner layer (30.6%). In regard of the gloves' sizes, the most frequent damage was found in size 8 (50%) followed by in size 7.5 (44.4%).

Table 5. Frequency distribution of the damaged gloves based on gloves' damage shape, inner and outer layers and sizes in hand plating operations

		Damage Shape		Total
		PUNCTURE	RUPTURE	
Damaged gloves		18	18	36
		50.0%	50.0%	100.0%
Layer				Total

	OUTER		INNER				
Damaged gloves	25 69.4%		11 30.6%				36 100.0%
	Size						Total
	6.0	6.5	7.0	7.5	8.0	8.5	
Damaged gloves	0 0.0%	0 0.0%	1 2.8%	16 44.4%	18 50.0%	1 2.8%	36 100.0%

(* a significance level below 0.05 has been considered for P-Pierson's chi square test and Fisher's exact test)

From the 36 cases of the damaged gloves in hand surgeries, 23 gloves (63.9%) had only one damage, 12 gloves (33.3%) had two damages and one glove (2.8%) had three damages. The total number of the observed damages in the hand orthopedic surgeries for the entire 36 damaged gloves was 50. Also, the highest number of the surgical gloves damages was found in thumb, forefinger and wrist, respectively [table 6].

Table 6. Frequency distribution of the damaged gloves based on the damage position during hand plating operations

Location	Damage		Total
	Yes	No	
LITTLE Finger	1 2.8%	35 97.2%	36 100.0%
MID Finger	1 2.8%	35 97.2%	36 100.0%
INDEX Finger	15 41.7%	21 58.3%	36 100.0%
THUMB Finger	18 50.0%	18 50.0%	36 100.0%
PALM	5 13.9%	31 86.1%	36 100.0%
BACKHAND	4 11.1%	32 88.9%	36 100.0%
CUFF	7 19.4%	29 80.6%	36 100.0%

The average time after which the gloves with apparent damage were discarded was 52.17 ± 6.66 . Also, from the 12 cases of apparent damages in the surgical gloves the highest number happened during a time span from 30 to 60 minutes of the operation onset. The results pertaining to the apparent damage based on time span are illustrated in (diagram 1).

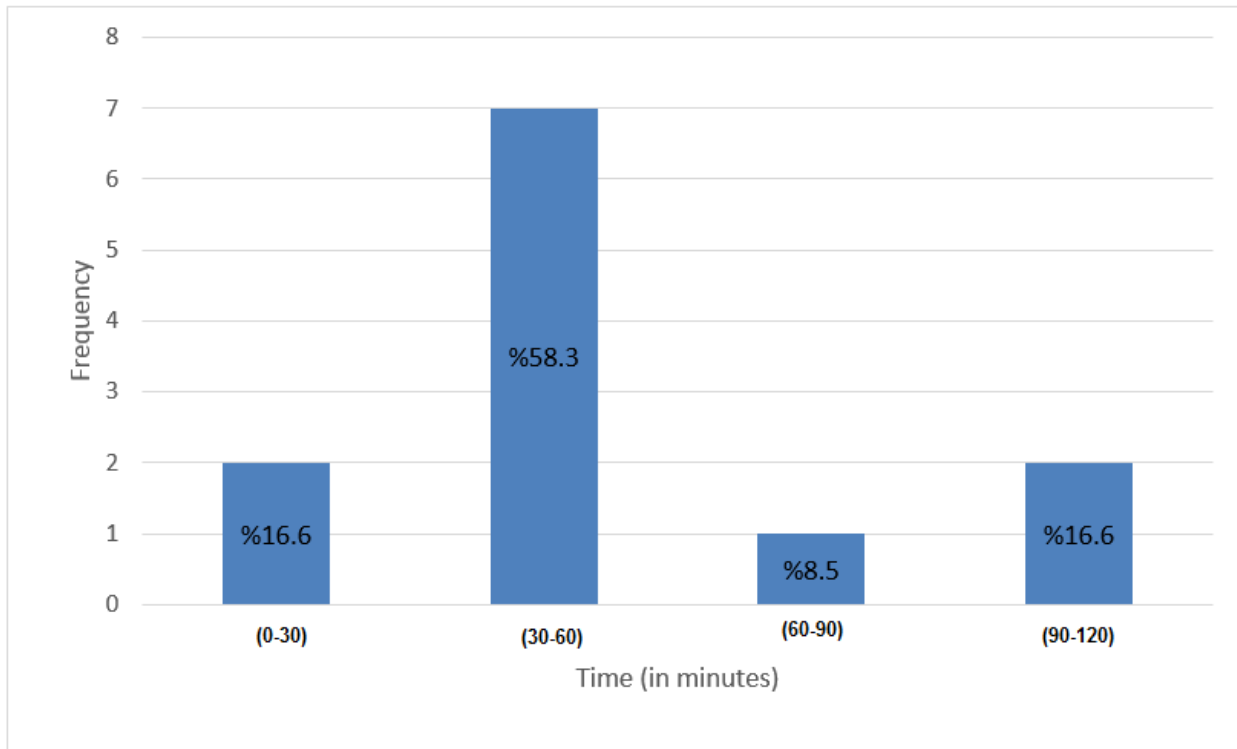


Diagram 1. The frequency of surgical gloves' apparent damaging based on time span during hand plating operations

Also, it was observed that, in a 5% significance level, there is a significant difference ($P\text{-value} = 0.001 < 0.05$) between the gloves with latent damage and gloves without damages in terms of the average time after which the gloves with no apparent damages were discarded in such a way that the average time after which the gloves with latent damages were discarded (122.33 ± 6.26 min) was found significantly higher than the average time after which the intact gloves were discarded (106.1 ± 2.63 min).

Foot Plating

It was observed in 5% significance level that the frequency distribution of the damaged gloves in scrubbed individuals (19.4%) was significantly smaller ($*P < 0.05$) than the assistant surgeons (46.3%) and surgeons (34.3%). In terms of the gloves' hand orientation, the frequency of the damage emergence in both left and right hand orientation was not indicative of any significant difference ($P > 0.05$). However, the damage frequency in the right hand gloves (56.7%) was higher than the left hand gloves (43.3%) but the difference was not statistically found significant. From all the 67 damaged gloves, 39 ones (58.2%) pertained to the dominant hand and 28 gloves (41.8%) pertained to the non-dominant hand. Based on this, the frequency of damage appearance was higher in the dominant hand gloves than the non-dominant hand gloves. The results of the distribution frequency related to the dominant hand gloves' damages are given in (table 7).

Table 7. Frequency distribution of the damaged gloves based on the role of the individuals and the gloves hand orientation in foot plating surgeries

		ROLE			Total	P-value
		SURGEON	ASIST	SCRUB		
Damaged gloves	No	41 32.8%	33 26.4%	51 40.8%	125 100.0%	0.002*
	Yes	23 34.3%	31 46.3%	13 19.4%	67 100.0%	
Total		64 33.3%	64 33.3%	64 33.3%	192 100.0%	
		SIDE		Total	P-value	
		RIGHT	LEFT			
Damaged gloves	No	58 46.4%	67 53.6%	125 100.0%	0.173	
	Yes	38 56.7%	29 43.3%	67 100.0%		
Total		96	96	192		

	50.0%	50.0%	100.0%
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(* a significance level below 0.05 has been considered for P-Pierson's chi square test and Fisher's exact test)

Table 8. Frequency distribution of the damages based on dominant hand in foot plating surgeries

	Dominant	Not dominant	Total	p-value
Damaged gloves	39	28	67	0.001*
	58.2%	42.8%	100%	

(* a significance level below 0.05 has been considered for P-Pierson's chi square test and Fisher's exact test)

(**table 8**) indicates that the frequency of the damage occurrence in the dominant hand significantly differed in regard of the gloves' hand orientation, left or right (*P<0.05) in such a manner that the damage frequency has been found higher when the right hand was the dominant hand in the operation team than the case where the left hand was found the dominant hand in the operation team members.

The results indicated that from the 67 damaged gloves during the foot plating operations, the damage frequency in the form of puncturing (73.1%) was found a lot higher than the damage frequency in the form of rupture (26.9%). The damage emergence frequency in the outer layer of the gloves (74.6%) was significantly (P<0.05) higher than the inner layer (25.4%). As for the gloves' sizes, the highest number of the damages was reported in the size 8 gloves followed by the size 7.5 gloves (**table 9**).

Table 9. Frequency distribution of the gloves damaged based on the form of damage, layer and size during foot plating operations

	Damage Shape					Total
	PUNCTURE		RUPTURE			
Damage	49 73.1%		18 26.9%			67 100.0%
	Layer					Total
	OUTER		INNER			
Damage	50 74.6%		17 25.4%			67 100.0%
	Size					Total
	6.5	7.0	7.5	8.0	8.5	
Damage	2 3.0%	6 9.0%	22 32.8%	33 49.3%	4 6.0%	67 100.0%

(* a significance level below 0.05 has been considered for P-Pierson's chi square test and Fisher's exact test)

Table 10. The frequency distribution of the gloves damaged in foot plating surgeries based on damage position

Location	Damage		Total
	Yes	No	
LITTLE Finger	2 3.0%	65 97.0%	67 100.0%
RING FINGER	4 6.0%	63 94.0%	67 100.0%
MID FINGER	4 6%	63 94%	67 100.0%
INDEX Finger	29 43.3%	38 56.7%	67 100.0%
THUMB Finger	28 41.8%	39 58.2%	67 100.0%
PALM	16 23.9%	51 76.1%	67 100.0%
BACKHAND	3 4.5%	64 95.5%	67 100.0%
CUFF	10 14.9%	57 85.1%	67 100.0%

In regard of the damage location, the index finger and thumb were found with the highest damage frequency [**table 10**]. From the 67 surgical gloves damage cases in foot plating surgeries, only one damage was found in 47 gloves (70.1%), two damages were reported in 12 gloves (17.9%), three damages were found in 7 gloves (10.4%) and only one pair of gloves (1.5%) was

found with four damages, with the total number of the observed damages during foot orthopedic surgeries for all the 67 damaged gloves reaching to 93.

As for the time, the average time after which the gloves with apparent damages had been discarded was 55.57 ± 6.85 minutes. Also, from the 22 apparent damages that occurred during the foot plating surgeries, the highest damage frequency was found to have taken place in a 60 to 90 minute time span, with ten damage cases, followed by the 0 to 30 minute time span, with 6 damage cases. The results pertaining to apparent damages during various temporal spans are illustrated in (**diagram 2**).

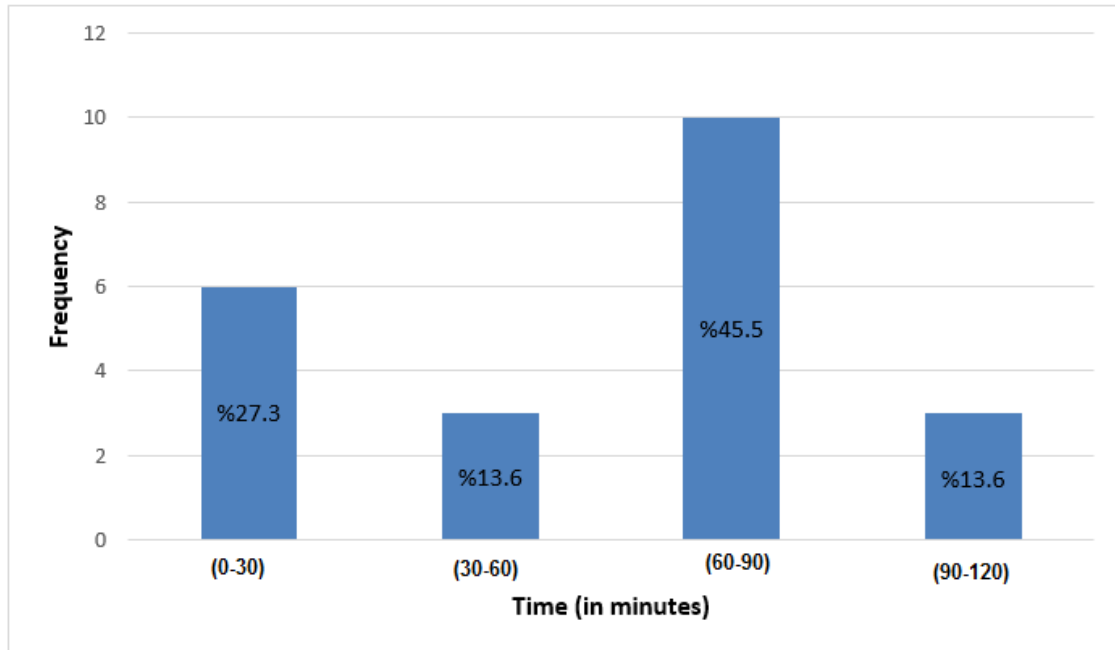


Diagram 2. Apparent damage frequency of the surgical gloves based on time spans during foot plating surgeries

T-test for two independent samples showed in a 5% significance level that there is no significant difference between the gloves with the latent damages and the undamaged ones during the orthopedic surgeries in terms of the average glove discarding time ($P > 0.05$), with the average gloves discarding time for the gloves with latent damage equal to 94.52 ± 4.86 and 98.21 ± 2.61 for the undamaged gloves.

Discussion

The present study is a descriptive-analytical research that dealt with the survey of the surgical gloves' damage rate during two general sets of hand and foot plating surgeries in Ayatollah Kashani Hospital associated with Isfahan's Medical Sciences and Healthcare Services University.

In the present study the entire surgeons and assistant surgeons were men, presumably due to the greater interest and participation of the gentlemen in orthopedic surgery discipline. But, the great majority of the scrubbed individuals, 65.6%, were women. The low rate of work history has been due to the reason that the majority of the respondents were surgery residents.

The results obtained herein indicated that surgical gloves damage rate during orthopedic plating procedures has been 26.8% and this is in a rate higher than what is usually found in the other surgeries [16-17]. Also, the damage rate was found higher in foot plating procedures than hand plating surgeries. This is reflective of the importance of the surgery type in the surgical gloves' damage rate. The largeness of the damage percentage in foot plating procedures can be a result of such surgeries being naturally heavier or longer. The results of the study performed by Choudhari and Padia who investigated the surgical gloves' damage during various hand and foot surgical procedures complying with the present study are indicative of the difference in the damage percentage during various orthopedic surgeries [8]. The other studies, as well, confirm the difference in the gloves' damage rate based on various types of surgical procedures [12].

The present study calculated a value equal to 34.9% as the surgical gloves' damage rate during foot plating procedures and this latter finding is somewhat against what has been reported in the study conducted by Lee et al. The results of the study undertaken by Lee et al on foot and leg fracture surgical procedures showed that 23 (25%) gloves out of 95 surgical gloves were found damaged in the foot fracture surgical procedures [14]. The difference in the results found herein and the results obtained by Lee et al can be due to the different study conditions. Also, the current research paper found a value equal to 18.8% for the damage percentage of the surgical gloves during the hand plating procedures. This result is consistent with what was reported in the study by Yinusa et al who reported a value equal to 19.4% for the surgical gloves' damage rate [13].

But the gloves' damage percentage in both sets of hand and foot surgical procedures was shown to be in its highest for assistant surgeons and in its lowest amount for scrubbed individuals. The low damage rate in scrubbed individuals seems to be due to the low intensity and frequency of the activities and interventions they are required to take during surgical procedures. The high damage percentage in assistant surgeons in respect to the surgeons complies with the results found by D'souza et al who reported that the damage percentage is higher in the interior layer for assistant surgeons who donned two-layer gloves in contrast to the surgeons [6]. Of course, a great many of the other researches [1&8], quite unlike the present study, showed that the damage percentage is higher in the gloves wore by the surgeons than the other groups. The largeness of the damage percentage in the current research paper in the assistant surgeons can be a result of a greater deal of responsibility and work assigned to them as well as their longer presence in the orthopedic surgeries.

In regard of the gloves' damage location, the results demonstrated that the damage rate is higher in thumb and forefinger regions during the hand plating surgical procedures. In foot plating surgical procedures, the results are well indicative of the larger rate of damage in index finger, thumb and palm areas in contrast to the other parts. The results obtained herein concerning the damage percentage in various locations of surgical gloves in both sets of these surgeries are completely consistent with the results obtained in the studies by Sanallah et al [9]. The larger rate of damage in such locations of the surgical gloves can be due to the more frequent involvement of these parts of the gloves and their repetitive contact with sharp and damaging tools as well as their being in a longer and continuous contact with the patients' tissues and bones.

The results indicated that the damage rate is higher in the outer layer of the gloves in both sets of the hand and foot plating surgical procedures than the inner layer and this is suggestive of the usefulness of wearing two layer surgical gloves. This is consistent with the results found by D'souza et al who estimated 11.9% and 2.38% respectively for the inner and outer layers of the surgical gloves [6].

Regarding the surgical gloves' damage shape, it was observed that puncturing and rupturing are very common in different hand plating surgical procedures and puncturing is more frequently observed than tearing in foot plating procedures. This is reflective of the fact that a great deal of the damages occurs in the form of punctures and this makes the recognition of surgical gloves' damaging a lot more difficult.

In terms of the surgical gloves' damaging according to the gloves' size, the damage rate was found to be higher in sizes 8 and 7.5 in both sets of surgical procedures. In the researcher's mind, this is due to the greater use of these gloves' sizes by the surgeons, assistant surgeons and naturally the increasingly higher percentage of damage in such sizes. This is due to the fact that the entire surgeons and assistant surgeons were men in the current research paper and the majority of the scrubbed individuals were women and this is a cause that gives rise to the difference in the damage rate in such surgical gloves' sizes.

In the present study, the damage frequency was found higher in the right hand in comparison to the left hand in both sets of hand and foot plating sets; moreover, the damage rate was higher in the dominant hand in contrast to the non-dominant hand and this is complying with the results obtained in the studies performed by Choudhari and Padia and inconsistent with the results obtained by Pai and Dhar [4, 8&1]. It appears that the larger rate of damage in the right hand is for the reason that the majority of the individuals studied herein were right-handed.

Regarding the time duration of the hand plating surgical procedures, the results indicated that the highest peak of the surgical gloves damaging happens in a time span from 30 to 60 minutes which is between 60 and 90 minute for foot plating surgical procedures. This can be due to reiterative contacts between the operation team members' gloves with the damaging tools or the patients' damaging tissues within this time intervals. The results of some other researches, unlike what was pointed out in here, are suggestive of the idea that the damages get higher in number and become more intensive with the increase in time [1, 16]. This can be due to the fact that all of the damaged gloves, with apparent and latent damages, have been taken into consideration in various time intervals in those studies; whereas, the present study only dealt with the gloves with apparent damages in respect to various time intervals. Of course, the results of the study carried out by Dhar, complying with the results presented in the current research paper, demonstrate that the damage rate does not increase with the increase in time and the damage rate differs and is even lower for various time intervals after the onset of surgery [4]. The average time for apparent damage to the gloves for both sets of the hand and foot plating operation was between 50 minutes to 60 minutes and this is reflective of the highest apparent damage risk for the operation team members' gloves during this period of time. The results obtained on the surgical gloves' apparent damages are indicative of shorter average times in the studies conducted by Han et al [15]. This seems to be a result of the difference in the operation type and the study environment.

Final Conclusion

Due to the high rate of gloves' damages during orthopedic plating surgeries, it is necessary to check and replace, if required, the gloves during this set of the surgical operations. Donning two-layer gloves is a useful method that brings about a reduction in the damage to the inner layer of the gloves and thus mitigates the needle sticking injuries and finally lowers the likelihood of dangerous infections' transfer. According to the fact that various risk factors play roles in damages imposed to the surgical gloves, it is suggested that the operation team members should be always cautious and careful about the damages in their dominant hands as well as in areas such as their thumbs and forefingers where greater contacts are made with the surgery instrument and the patients' bodies during the surgical operations. Based on the results obtained in the current research paper, it is recommended that the surgical gloves should be replaced within 30 to 60 minute-time intervals during hand plating surgeries and within 60 to 90-minute time intervals during foot plating surgeries or generally on a regular basis.

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Infections transferred during surgeries from the patient to the surgeons can be considered as occupational injuries. Operating room surgeons and personnel are in a high risk of being exposed to patients' blood and body liquids. Surgical gloves have been increasingly advanced to protect the individuals' hands against infections transferrable from the patients. In other words, preventing the infections from transferring to the operation team has increased in its significance. Specific conditions of every surgery and longer periods of contact to blood mean higher risks of blood pathogens' transfer [1]. Thus, being exposed to the blood pathogens by the personnel is regarded as one of the serious dangers that should be placed atop of the prevention priority lists [2]. Although healthy skin acts as a good barrier to the infiltration of pathogenic agents the existence of a small microscopic scratch on the skin surface can act as a deep groove through which the microorganisms can penetrate which can cause the emergence of skin-related infections or systemic ailments [3]. There are high concerns for the transferring of infections between the operation team and patients [4] and there is also the risk of infectious pathogens transfer between the two foresaid groups and such a risk can be decreased by means of barriers and protectors [5]. Surgical gloves prevent the operation team members' hands from getting in touch with the patients' blood and they act as protective barriers against the blood pathogens such as AIDS, Hepatitis B and hepatitis C [6]. Furthermore, surgical gloves are good protective barriers saving the healthcare personnel and patients against infectious secretions during emergency operations [7]. Statistics indicate that the risk of being infected with viruses as a result of needle sticking injuries for AIDS, Hepatitis B and Hepatitis C are 0.3%, from 6% to 37% and 1% to 2%, respectively [8].

Studies show that the frequent use of the puncturing instruments during orthopedic surgeries such as nails, wires, saws or needles increases the transferring risk of infections such as HIV, HBV and HCV [9]. In addition, the operation team members are also exposed to the risk of gloves damaging during the surgeries and it seems that the surgeons are inter alia subjected to the highest risk of such dangers as a result of frequent manual activities and repetitive application of sharp tools during surgeries [10].

There are numerous contributing and risk factors associated with the surgical gloves damaging among which the roles of time, individuals during operations, the use of one-layer or two-layer surgical gloves, the type of the operation, namely emergency or elective, can be pointed out [8&6].

The results of the studies performed by Choudhari and Padia demonstrated that the total rate of the surgical gloves damaging is 9.4%, with the highest rate, 45%, going to the gloves used by the surgeons and the lowest rate, 4.5%, being calculated for the scrubbing individuals. Gloves' damage rate 100 minutes after the onset of the operation was found 67% and a rate equal to 30.4% was obtained before 100 minutes of the onset of the operation. The highest rate of damage was found belonging to the forefinger and the dominant hand in the current research paper [8].

The results obtained by D'souza et al indicated that the damage rates for groups of surgeons, assistant surgeon and nurses who had used single surgical gloves were 25%, 11% and 10%, respectively and they have been computed 1.58%, 4% and 2.72%, respectively, for the groups that had used two pairs of gloves. Additionally, the damage rate was found 46.66% in surgeries that lasted more than 90 minutes and a rate of 18.94% was figured out in operations that finished in a period below 90 minutes [6].

The results of the studies carried out by Kaya et al, in 2011, showed that 32 gloves were found damaged during 19 surgeries. Among the damaged gloves, 28 ones were belonged to the surgeons and assistant surgeons. In the present study, 81.3% of the damages were seen in the thumb and forefinger areas. There was no significant difference found between the two groups, joint replacement and reconstruction operations, regarding the time of making use of the gloves, the number of the damaged gloves and the surgery duration [11].

Prior research is reflective of the triviality of the studies regarding the orthopedic plating operations. Also, the results obtained for the extent to which the gloves are damaged in various kinds of surgical operations [12] and their classification based on variegated risk factors are complying in some cases and incompliant in others [6, 13-14 and 15]. Some of these risk factors encompass the types of the material used in gloves, the inner and outer layers of the gloves, surgical procedure type, and operation time, the role of the individuals in surgeries and individuals' dominant hands. Having a clear understanding of the various risk factors can be considerably helpful in lowering the risk of gloves' damaging and the reduction in the infections' transfer between the operation team members and patients. The present study aims at the survey of the rate to which the surgical gloves are damaged due to various factors during the hand and foot plating orthopedic surgeries.

Study Method

The current research paper has been carried out based on a descriptive-analytical method in 2016 in an orthopedics and nerves operating room in Ayatollah Kashani Hospital associated with Isfahan's Medical Sciences and Treatment Services University.

The study sample volume included 384 gloves that had been worn by the scrubbed individuals present in hand and foot plating operations. Out of the 384 gloves, 192 ones were used in hand plating and 192 ones were used in foot plating operations. In each of these two sets of surgeries, 64 gloves belonged to the surgeons, 64 ones to the assistant surgeons and 64 others were from the scrubbed individuals. A total of 12 samples were taken from each surgery out of which four belonged to the surgeons, four to the assistant surgeons and four to the scrubbed individuals. The four samples belonging to each of the individuals included the inner right gloves, the inner left gloves, the outer right and the outer left gloves. The entire gloves were made of two layers and all had the same material. After each one of the gloves were taken off, the reason and the time of the gloves' removal were recorded. However, only the outer layer of the gloves was replaced during the operation and the new gloves were not taken into consideration for further investigation. Data collection tool was comprised of researcher-made questionnaire and checklist.

Questionnaire included the demographic information pertaining to the surgery as well as to the operation team members and the checklist embraced items pertaining to the surgical gloves damages. The questionnaire contained items regarding the type of the surgery, the number of the scrubbed individuals present during the operation, dominant hand, gender and the individuals' work history. Checklist contained items pertaining to the gloves' damages including the roles of the individuals present during the operation, gloves hand orientation (left or right), the gloves being used interiorly or exteriorly and their sizes; also, including the shape, position, the number of the damaged points on the gloves and the time the damage had occurred.

The gloves were labeled after being discarded by the individuals and they were transferred to outside the operating room for the purpose of undergoing water leak test which is a standard method for analyzing the surgical gloves around the globe [10].

The study inclusion scales were the shortness of the operation team members' nails, the presence of the operation team members from the very beginning, the elective nature of the surgeries, not manually working with tools damaging the gloves and use of identical materials in the entire gloves. Study exclusion scales were the illegibility of the gloves' labels, the imperfect preparation of the data pertaining to each of the gloves and conducting processes other than what had been specified for the main intervention that was to be carried out on the patient during the surgery.

To analyze the data, the following statistical tests were undertaken: Pierson's chi-square test, Fisher's exact test and t-tests for two independent samples and the data were analyzed by means of SPSS software, version 22.

Results

The study sample volume selected in the current descriptive-analytical research was comprised of 384 surgical gloves used in 32 orthopedic surgeries and donned by scrubbed operation team members such as surgeons, first assistant surgeons and scrubbed individuals and they entered the study according to the study inclusion criteria. The samples were investigated for the damage rate due to various factors during hand and foot plating operations performed in Isfahan's Ayatollah Kashani Treatment and Educational Center in 2016. From the 384 studied gloves, 192 gloves (50%) were from the hand plating operations (16 surgeries) and 192 others (50%) were belonged to foot plating operation (16 surgical operations). The mean number of the scrubbed individuals in the entire 32 hand and foot orthopedic surgeries was 3.66 ± 0.139 , with the mean number of the scrubbed individuals in the 16 foot plating operation was 3.94 ± 0.123 and it has been 3.35 ± 0.155 in the entire hand plating operations. The results pertaining to the frequency distribution of the surgical team scrubbed individuals and their work histories and genders are given in [table 1].

Table 1. Frequency distribution of the demographic characteristics pertaining to the orthopedic surgery team members

		SEX		Total
		N (%)		
		Male	Female	
Role	SURGEON	32	0	32
		100.0%	0.0%	100.0%

	ASIST		32	0	32
			100.0%	0.0%	100.0%
	SCRUB		11	21	32
			34.4%	65.6%	100.0%
Total			75	21	96
			78.1%	21.9%	100.0%
			Role	Mena	Std. error of mean
			Surgeon (n=32)	6.38	1.22
Work history			Assist (n=32)	2.28	0.144
			Scrub (n=32)	12.53	2.14

The results pertaining to the damage frequency distribution of the surgical gloves used in the hand and foot orthopedic surgeries are presented in [table 2]. Chi-square tests were suggestive of a significant difference in terms of the frequency of the damages and the type of the surgery ($P\text{-value} = 0.001 < 0.05$); it means that gloves' damaging in hand plating operations was indicative of a frequency percentage equal to 34.9 which is higher than the frequency percentage obtained for hand plating surgeries, 18.8.

Table 2. Frequency distribution of the gloves damaged during the hand and foot plating operations

		Damage		Total	P-value
		No	Yes		
Surgery	Foot Surgery	125 65.1%	67 34.9%	192 100.0%	0.001*
	Hand Surgery	156 81.2%	36 18.8%	192 100.0%	
Total		281 73.2%	103 26.8%	384 100.0%	

(* a significance level below 0.05 has been considered for P-Pierson's chi square test)

Hand Plating Surgeries:

According to [table 3], it can be seen that, in 5% significance level, the frequency percentage of the gloves damaging in the scrubbed individuals (8.3%) is significantly ($*P < 0.05$) lower than what was found for assistant surgeons (47.2%) and surgeons (44.4%). As for the hand orientation of the gloves, it was observed that the frequency of the damage appearance did not show any significant difference in both hand orientations ($P > 0.05$). However, it was found out that the damage frequency has been higher in right hand glove (61.1%) as compared to the left hand glove (38.9%).

From the total 36 damaged gloves, 28 gloves were belonged to the dominant hand and 8 gloves belonged to the non-dominant hand. Based on this, the frequency of the damage emergence was found higher in the gloves pertaining to the dominant hand as compared to the non-dominant hand. The results of the damage frequency distribution for dominant hand gloves are summarized in (table 4).

Table 3. Frequency distribution of the gloves damaged in hand plating surgeries based on the gloves' role and orientation

		ROLE			Total	P-value
		SURGEON	ASIST	SCRUB		
Damaged gloves	No	48	47	61	156	

		30.8%	30.1%	39.1%	100.0%	0.002*
	Yes	16	17	3	36	
		44.4%	47.2%	8.3%	100.0%	
Total		64	64	64	192	
		33.3%	33.3%	33.3%	100.0%	
		SIDE			Total	P-value
		RIGHT	LEFT			
Damaged gloves	No	74	82	156	0.139	
		47.4%	52.6%	100.0%		
	Yes	22	14	36		
		61.1%	38.9%	100.0%		
Total		96	96	192		
		50.0%	50.0%	100.0%		

(* a significance level below 0.05 has been considered for P-Pierson's chi square test and Fisher's exact test)

Table 4. Frequency distribution of the damages based on dominant hand in hand plating operations

	Dominant	Not dominant	Total	p-value
Damaged gloves	28	8	36	0.003*
	77.8%	22.2%	100%	

(* a significance level below 0.05 has been considered for P-Pierson's chi square test and Fisher's exact test)

Corresponding to [table 5], it was observed that the damage frequency in the form of puncturing was identical to the damage frequency that was appeared in the form of rupture in all of the 36 damaged gloves. The frequency of the damage emergence in the outer layer of the gloves (69.4%) was significantly (P-value = 0.010 < 0.05) higher than the inner layer (30.6%). In regard of the gloves' sizes, the most frequent damage was found in size 8 (50%) followed by in size 7.5 (44.4%).

Table 5. Frequency distribution of the damaged gloves based on gloves' damage shape, inner and outer layers and sizes in hand plating operations

	Damage Shape		Total
	PUNCTURE	RUPTURE	
Damaged gloves	18	18	36
	50.0%	50.0%	100.0%
	Layer		Total
	OUTER	INNER	
Damaged gloves	25	11	36
	69.4%	30.6%	100.0%

	Size						Total
	6.0	6.5	7.0	7.5	8.0	8.5	
Damaged gloves	0	0	1	16	18	1	36
	0.0%	0.0%	2.8%	44.4%	50.0%	2.8%	100.0%

(* a significance level below 0.05 has been considered for P-Pearson's chi square test and Fisher's exact test)

From the 36 cases of the damaged gloves in hand surgeries, 23 gloves (63.9%) had only one damage, 12 gloves (33.3%) had two damages and one glove (2.8%) had three damages. The total number of the observed damages in the hand orthopedic surgeries for the entire 36 damaged gloves was 50. Also, the highest number of the surgical gloves damages was found in thumb, forefinger and wrist, respectively (**table 6**).

Table 6. Frequency distribution of the damaged gloves based on the damage position during hand plating operations

Location	Damage		Total
	Yes	No	
LITTLE Finger	1 2.8%	35 97.2%	36 100.0%
MID Finger	1 2.8%	35 97.2%	36 100.0%
INDEX Finger	15 41.7%	21 58.3%	36 100.0%
THUMB Finger	18 50.0%	18 50.0%	36 100.0%
PALM	5 13.9%	31 86.1%	36 100.0%
BACKHAND	4 11.1%	32 88.9%	36 100.0%
CUFF	7 19.4%	29 80.6%	36 100.0%

The average time after which the gloves with apparent damage were discarded was 52.17 ± 6.66 . Also, from the 12 cases of apparent damages in the surgical gloves the highest number happened during a time span from 30 to 60 minutes of the operation onset. The results pertaining to the apparent damage based on time span are illustrated in (**diagram 1**).

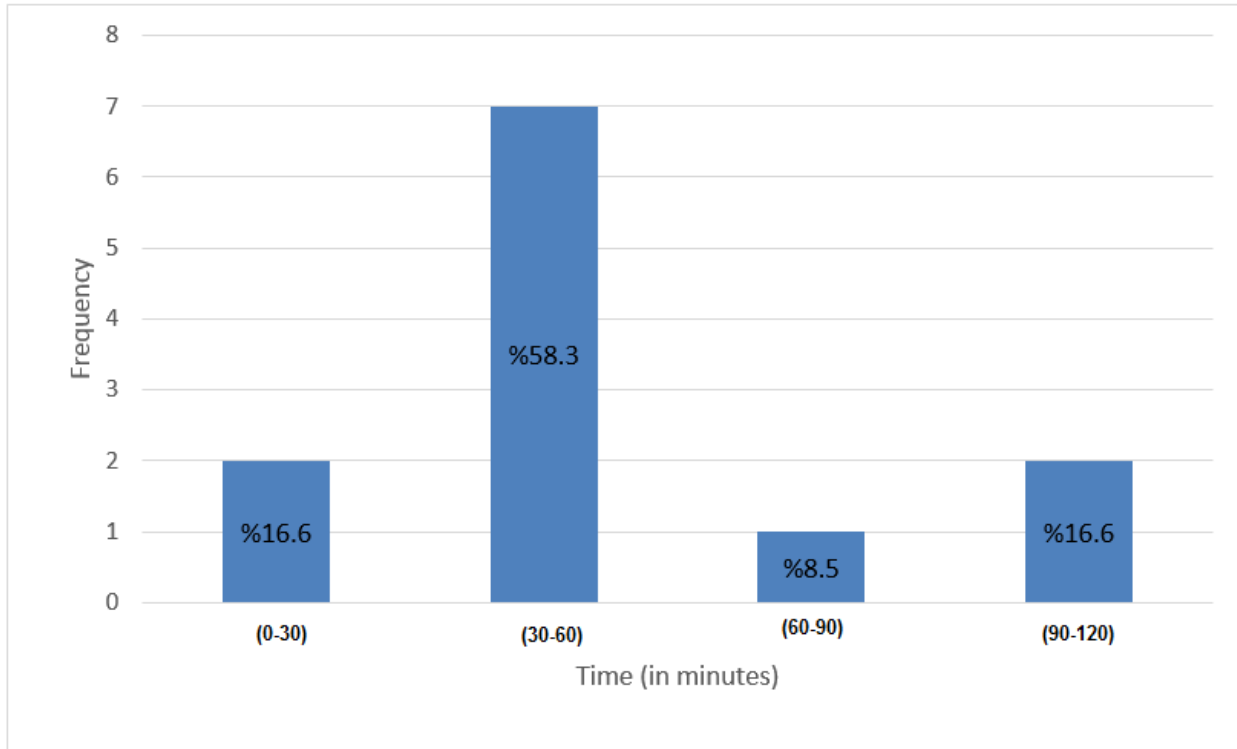


Diagram 1. The frequency of surgical gloves' apparent damaging based on time span during hand plating operations

Also, it was observed that, in a 5% significance level, there is a significant difference ($P\text{-value} = 0.001 < 0.05$) between the gloves with latent damage and gloves without damages in terms of the average time after which the gloves with no apparent damages were discarded in such a way that the average time after which the gloves with latent damages were discarded (122.33 ± 6.26 min) was found significantly higher than the average time after which the intact gloves were discarded (106.1 ± 2.63 min).

Foot Plating

It was observed in 5% significance level that the frequency distribution of the damaged gloves in scrubbed individuals (19.4%) was significantly smaller ($*P < 0.05$) than the assistant surgeons (46.3%) and surgeons (34.3%). In terms of the gloves' hand orientation, the frequency of the damage emergence in both left and right hand orientation was not indicative of any significant difference ($P > 0.05$). However, the damage frequency in the right hand gloves (56.7%) was higher than the left hand gloves (43.3%) but the difference was not statistically found significant. From all the 67 damaged gloves, 39 ones (58.2%) pertained to the dominant hand and 28 gloves (41.8%) pertained to the non-dominant hand. Based on this, the frequency of damage appearance was higher in the dominant hand gloves than the non-dominant hand gloves. The results of the distribution frequency related to the dominant hand gloves' damages are given in (table 7).

Table 7. Frequency distribution of the damaged gloves based on the role of the individuals and the gloves hand orientation in foot plating surgeries

		ROLE			Total	P-value
		SURGEON	ASIST	SCRUB		
Damaged gloves	No	41 32.8%	33 26.4%	51 40.8%	125 100.0%	0.002*
	Yes	23 34.3%	31 46.3%	13 19.4%	67 100.0%	

Total		64 33.3%	64 33.3%	64 33.3%	192 100.0%	
		SIDE			Total	P-value
		RIGHT	LEFT			
Damaged gloves	No	58 46.4%	67 53.6%		125 100.0%	0.173
	Yes	38 56.7%	29 43.3%		67 100.0%	
Total		96 50.0%	96 50.0%		192 100.0%	

(* a significance level below 0.05 has been considered for P-Pierson's chi square test and Fisher's exact test)

Table 8. Frequency distribution of the damages based on dominant hand in foot plating surgeries

	Dominant	Not dominant	Total	p-value
Damaged gloves	39	28	67	0.001*
	58.2%	42.8%	100%	

(* a significance level below 0.05 has been considered for P-Pierson's chi square test and Fisher's exact test)

(table 8) indicates that the frequency of the damage occurrence in the dominant hand significantly differed in regard of the gloves' hand orientation, left or right (*P<0.05) in such a manner that the damage frequency has been found higher when the right hand was the dominant hand in the operation team than the case where the left hand was found the dominant hand in the operation team members.

The results indicated that from the 67 damaged gloves during the foot plating operations, the damage frequency in the form of puncturing (73.1%) was found a lot higher than the damage frequency in the form of rupture (26.9%). The damage emergence frequency in the outer layer of the gloves (74.6%) was significantly (P<0.05) higher than the inner layer (25.4%). As for the gloves' sizes, the highest number of the damages was reported in the size 8 gloves followed by the size 7.5 gloves (table 9).

Table 9. Frequency distribution of the gloves damaged based on the form of damage, layer and size during foot plating operations

	Damage Shape		Total
	PUNCTURE	RUPTURE	
Damage	49 73.1%	18 26.9%	67 100.0%
	Layer		Total
	OUTER	INNER	
Damage	50 74.6%	17 25.4%	67 100.0%
	Size		Total

	6.5	7.0	7.5	8.0	8.5	
Damage	2	6	22	33	4	67
	3.0%	9.0%	32.8%	49.3%	6.0%	100.0%

(* a significance level below 0.05 has been considered for P-Pierson's chi square test and Fisher's exact test)

Table 10. The frequency distribution of the gloves damaged in foot plating surgeries based on damage position

Location	Damage		Total
	Yes	No	
LITTLE Finger	2 3.0%	65 97.0%	67 100.0%
RING FINGER	4 6.0%	63 94.0%	67 100.0%
MID FINGER	4 6%	63 94%	67 100.0%
INDEX Finger	29 43.3%	38 56.7%	67 100.0%
THUMB Finger	28 41.8%	39 58.2%	67 100.0%
PALM	16 23.9%	51 76.1%	67 100.0%
BACKHAND	3 4.5%	64 95.5%	67 100.0%
CUFF	10 14.9%	57 85.1%	67 100.0%

In regard of the damage location, the index finger and thumb were found with the highest damage frequency [table 10]. From the 67 surgical gloves damage cases in foot plating surgeries, only one damage was found in 47 gloves (70.1%), two damages were reported in 12 gloves (17.9%), three damages were found in 7 gloves (10.4%) and only one pair of gloves (1.5%) was found with four damages, with the total number of the observed damages during foot orthopedic surgeries for all the 67 damaged gloves reaching to 93.

As for the time, the average time after which the gloves with apparent damages had been discarded was 55.57 ± 6.85 minutes. Also, from the 22 apparent damages that occurred during the foot plating surgeries, the highest damage frequency was found to have taken place in a 60 to 90 minute time span, with ten damage cases, followed by the 0 to 30 minute time span, with 6 damage cases. The results pertaining to apparent damages during various temporal spans are illustrated in [diagram 2].

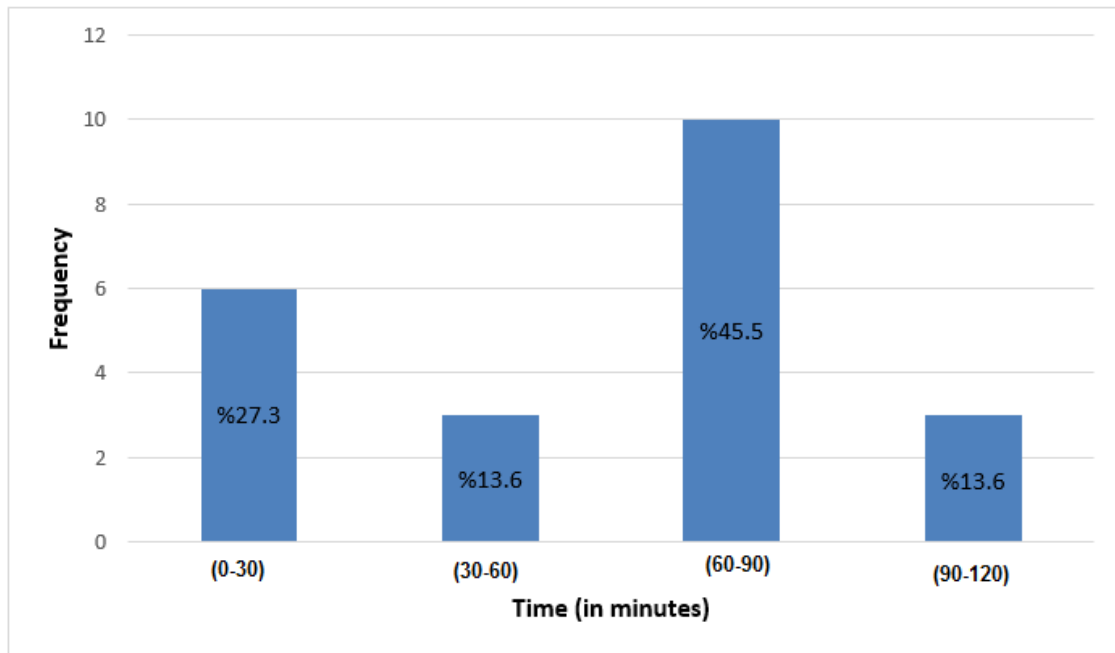


Diagram 2. Apparent damage frequency of the surgical gloves based on time spans during foot plating surgeries

T-test for two independent samples showed in a 5% significance level that there is no significant difference between the gloves with the latent damages and the undamaged ones during the orthopedic surgeries in terms of the average glove discarding time ($P > 0.05$), with the average gloves discarding time for the gloves with latent damage equal to 94.52 ± 4.86 and 98.21 ± 2.61 for the undamaged gloves.

Discussion

The present study is a descriptive-analytical research that dealt with the survey of the surgical gloves' damage rate during two general sets of hand and foot plating surgeries in Ayatollah Kashani Hospital associated with Isfahan's Medical Sciences and Healthcare Services University.

In the present study the entire surgeons and assistant surgeons were men, presumably due to the greater interest and participation of the gentlemen in orthopedic surgery discipline. But, the great majority of the scrubbed individuals, 65.6%, were women. The low rate of work history has been due to the reason that the majority of the respondents were surgery residents.

The results obtained herein indicated that surgical gloves damage rate during orthopedic plating procedures has been 26.8% and this is in a rate higher than what is usually found in the other surgeries [16-17]. Also, the damage rate was found higher in foot plating procedures than hand plating surgeries. This is reflective of the importance of the surgery type in the surgical gloves' damage rate. The largeness of the damage percentage in foot plating procedures can be a result of such surgeries being naturally heavier or longer. The results of the study performed by Choudhari and Padia who investigated the surgical gloves' damage during various hand and foot surgical procedures complying with the present study are indicative of the difference in the damage percentage during various orthopedic surgeries [8]. The other studies, as well, confirm the difference in the gloves' damage rate based on various types of surgical procedures [12].

The present study calculated a value equal to 34.9% as the surgical gloves' damage rate during foot plating procedures and this latter finding is somewhat against what has been reported in the study conducted by Lee et al. The results of the study undertaken by Lee et al on foot and leg fracture surgical procedures showed that 23 (25%) gloves out of 95 surgical gloves were found damaged in the foot fracture surgical procedures [14]. The difference in the results found herein and the results obtained by Lee et al can be due to the different study conditions. Also, the current research paper found a value equal to 18.8% for the damage percentage of the surgical gloves during the hand plating procedures. This result is consistent with what was reported in the study by Yinusa et al who reported a value equal to 19.4% for the surgical gloves' damage rate [13].

But the gloves' damage percentage in both sets of hand and foot surgical procedures was shown to be in its highest for assistant surgeons and in its lowest amount for scrubbed individuals. The low damage rate in scrubbed individuals seems to be due to the low intensity and frequency of the activities and interventions they are required to take during surgical procedures. The high damage percentage in assistant surgeons in respect to the surgeons complies with the results found by D'souza et al who reported that the damage percentage is higher in the interior layer for assistant surgeons who donned two-layer gloves in contrast to the surgeons [6]. Of course, a great many of the other researches [1&8], quite unlike the present study, showed that the damage percentage is higher in the gloves wore by the surgeons than the other groups. The largeness of the damage percentage in the current research paper in the assistant surgeons can be a result of a greater deal of responsibility and work assigned to them as well as their longer presence in the orthopedic surgeries.

In regard of the gloves' damage location, the results demonstrated that the damage rate is higher in thumb and forefinger regions during the hand plating surgical procedures. In foot plating surgical procedures, the results are well indicative of the larger rate of damage in index finger, thumb and palm areas in contrast to the other parts. The results obtained herein concerning the damage percentage in various locations of surgical gloves in both sets of these surgeries are completely consistent with the results obtained in the studies by Sanaullah et al [9]. The larger rate of damage in such locations of the surgical gloves can be due to the more frequent involvement of these parts of the gloves and their repetitive contact with sharp and damaging tools as well as their being in a longer and continuous contact with the patients' tissues and bones.

The results indicated that the damage rate is higher in the outer layer of the gloves in both sets of the hand and foot plating surgical procedures than the inner layer and this is suggestive of the usefulness of wearing two layer surgical gloves. This is consistent with the results found by D'souza et al who estimated 11.9% and 2.38% respectively for the inner and outer layers of the surgical gloves [6].

Regarding the surgical gloves' damage shape, it was observed that puncturing and rupturing are very common in different hand plating surgical procedures and puncturing is more frequently observed than tearing in foot plating procedures. This is reflective of the fact that a great deal of the damages occurs in the form of punctures and this makes the recognition of surgical gloves' damaging a lot more difficult.

In terms of the surgical gloves' damaging according to the gloves' size, the damage rate was found to be higher in sizes 8 and 7.5 in both sets of surgical procedures. In the researcher's mind, this is due to the greater use of these gloves' sizes by the surgeons, assistant surgeons and naturally the increasingly higher percentage of damage in such sizes. This is due to the fact that the entire surgeons and assistant surgeons were men in the current research paper and the majority of the scrubbed individuals were women and this is a cause that gives rise to the difference in the damage rate in such surgical gloves' sizes.

In the present study, the damage frequency was found higher in the right hand in comparison to the left hand in both sets of hand and foot plating sets; moreover, the damage rate was higher in the dominant hand in contrast to the non-dominant hand and this is complying with the results obtained in the studies performed by Choudhari and Padia and inconsistent with the results obtained by Pai and Dhar [4, 8&1]. It appears that the larger rate of damage in the right hand is for the reason that the majority of the individuals studied herein were right-handed.

Regarding the time duration of the hand plating surgical procedures, the results indicated that the highest peak of the surgical gloves damaging happens in a time span from 30 to 60 minutes which is between 60 and 90 minute for foot plating surgical procedures. This can be due to reiterative contacts between the operation team members' gloves with the damaging tools or the patients' damaging tissues within this time intervals. The results of some other researches, unlike what was pointed out in here, are suggestive of the idea that the damages get higher in number and become more intensive with the increase in time [1, 16]. This can be due to the fact that all of the damaged gloves, with apparent and latent damages, have been taken into consideration in various time intervals in those studies; whereas, the present study only dealt with the gloves with apparent damages in respect to various time intervals. Of course, the results of the study carried out by Dhar, complying with the results presented in the current research paper, demonstrate that the damage rate does not increase with the increase in time and the damage rate differs and is even lower for various time intervals after the onset of surgery [4]. The average time for apparent damage to the gloves for both sets of the hand and foot plating operation was between 50 minutes to 60 minutes and this is reflective of the highest apparent damage risk for the operation team members' gloves during this period of time. The results obtained on the surgical gloves' apparent damages are indicative of shorter average times in the studies conducted by Han et al [15]. This seems to be a result of the difference in the operation type and the study environment.

Final Conclusion

Due to the high rate of gloves' damages during orthopedic plating surgeries, it is necessary to check and replace, if required, the gloves during this set of the surgical operations. Donning two-layer gloves is a useful method that brings about a reduction in the damage to the inner layer of the gloves and thus mitigates the needle sticking injuries and finally lowers the likelihood of dangerous infections' transfer. According to the fact that various risk factors play roles in damages imposed to the surgical

gloves, it is suggested that the operation team members should be always cautious and careful about the damages in their dominant hands as well as in areas such as their thumbs and forefingers where greater contacts are made with the surgery instrument and the patients' bodies during the surgical operations. Based on the results obtained in the current research paper, it is recommended that the surgical gloves should be replaced within 30 to 60 minute-time intervals during hand plating surgeries and within 60 to 90-minute time intervals during foot plating surgeries or generally on a regular basis.

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