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Prevalence and associated factors of surgical gloves perforation in elective orthopaedic and trauma surgeries done at KCMC, from November 2018 through May 2019; Prospective observational study

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Abstract

Background: Since medical history and examination can't reliably identify all patient harbouring blood-borne pathogens, universal precautions during exposure to blood and body fluid are now imperative. Intact surgical glove is an integral part aimed to protect patients from the surgical team members' microbial flora of the hand and mutually, surgical team members from pathogens of the patient's body, nevertheless surgical glove perforation is a major concern with a perforation rate as high as 50% has been reported in literature depending on the type of surgery. The risk of perforation is thought to correlates with many factors, yet very few prospective studies have addressed this issue at Kilimanjaro Christian Medical centre Hospital.

Objective: The intent of this study was to determine the prevalence and associated factors of surgical gloves perforation in elective orthopaedic and Trauma surgeries.

Methods: Prospective observational study design was conducted at Orthopaedics and Trauma operating theatres. Systematic sampling technique was used, after surgery inner and outer surgical gloves utilized by the surgical team were collected, labelled and tested by water leak test method (EN 455-1) consisting of visual evaluation of gloves after hydro insufflation.

Results; Total of 1672 surgical gloves were collected during the study period, overall perforations were found to be 17.1%, higher perforation seen in bone surgeries. Among the surgical team members, the highest perforation was seen in surgeons 49.7% with much involvement of index finger 36.9% followed by the thumb 21.1% in the non-dominant hand. Surgeries lasting longer than 90 minutes found to associate with a high proportion of surgical glove perforation.

Conclusion; Our results portray that there is a significant relationship between the type of surgery, the role of surgical a team member, the dominance of the hand, glove layer and the location of perforation with the prevalence of surgical glove perforation.

Keywords: Surgical gloves, glove perforation, orthopaedic surgery, disease transmission and double gloving

1. Introduction

Orthopaedic surgeons are endangered on a daily basis by body fluid with the inherit risk of getting infected with blood-borne pathogens, this is because of being in a prolonged contact with open surgical wounds, handling of sharps and complex equipment such as oscillating saw, sharp bony fragments, spraying of body fluids and tissue particles as well as wound fluids [1].

Studies they have reported prevalence of surgical glove perforation that range from 10% in ophthalmic surgeries to 50% in general surgery, while in orthopaedic surgery the prevalence range from 14% during paediatric orthopaedic surgeries to 57% during hip fracture surgeries and that surgical gloves need to be changed at a predetermined interval during elective

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¹ Ayoub M, Ort H S, Ort M A, Dabbebi F. and Dhiab M Ben (2017) Evaluation of surgical glove integrity and factors associated with glove defect American Journal of Infection Control Evaluation of surgical glove integrity and factors associated with glove defect, AJIC: American Journal of Infection Control, 46 (1), pp. 30-33. DOI:10.1016/j.ajic.2017.07.016.

orthopaedic and trauma surgeries [2, 2, 2]

Little is known about the prevalence of surgical glove perforation in elective orthopaedics and trauma surgeries at KCMC and there is no protocol of changing surgical glove in a predetermined time interval for longer surgeries thus in virtue of that the author is interested in finding out how common perforation of surgical gloves occurs and what are the associated factors at KCMC.

Medical literature found surgical glove perforation positively correlates with the duration of wear and recommended to be changed after 90 minutes of surgery because when they are stressed for a long duration their quality of the barrier become compromised [3].

Changing gloves at appropriate time interval is increasingly common but there is no protocol for changing surgical gloves at a predetermined interval during elective orthopedics and trauma surgeries at KCMC Hospital.

2. Materials and methods

This has been a prospective observational study that was conducted at KCMC consultant Hospital located in Kilimanjaro, Tanzania between November 2018 to May 2019. A total of 1672 surgical gloves were collected from 122 consecutive orthopaedic and trauma elective surgeries after being utilized by the surgeon, assistant surgeon and scrub nurse and then tested for perforations. Surgical gloves were collected after their removal by the wearer, separated, labelled and the identified in a plastic containers according to the type of surgery, the duration of their use, function of the wearer, inner or outer surgical glove and the surgical team member dominant hand for the activity, collected surgical glove were then tested using approved and standardized Water Leak Test (WLT) method (EN 455-1), this method has been approved by the European and normalization committee as well as Food and drugs Administration (FDA)

Each glove was filled with 1000 mills ± 50 mills of water at room temperature, gently squeezed to find out for the perforation in which case a positive perforation of surgical glove was defined in the presence of droplets or stream of water on the exterior aspect of the surgical glove. Data was analysed using Statistical Package for Social Science (IBM SPSS) version 20.0 and the significance level fixed at P<0.05, percentages and proportion were utilized to summarize categorical variables while measures of central tendencies and dispersion were used for continuous variables. Data finally presented in frequency tables and bar graphs.

3. Results

A total of 1,672 surgical gloves were collected from 122

² Partecke L I, Goerdts A M, Langner I, Jaeger B, Assadian O, Heidecke C D, Kramer A and Huebner N O. (2009) Incidence of microperforation for surgical gloves depends on duration of wear., *Infection Control and Hospital Epidemiology: The Official Journal of the Society of Hospital Epidemiologists of America*, 30 (5), pp. 409–14. DOI:10.1086/597062.

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³ Ode M B, Onche I I, Amupitan I, Mancha D G, Ismaila B. and Shuaibu S. (2013) Glove Punctures in Orthopedics and Trauma Surgery : Frequency and Nature of Occurrence, 12 (June), pp. 11–14.

consecutive elective orthopaedic surgical procedures with the median (range) number of gloves used per procedure being 4 (range of 1 to 17). Majority of the surgical team members were right-handed 1,597 (95.5%). Right outer glove perforation was 106 (6.3%), left outer glove perforation was 140 (8.4%), right inner glove perforation was 20 (1.2%) and left inner glove perforation was 21 (1.3%). Majority of the surgical gloves 1,588 (94.9%) were used in surgeries with < 90 minutes duration while 1,653 (98.9%) gloves were used in bone surgeries. In the entire study 611 (36.5%) of the surgical gloves were used by surgeons, (see Table 1).

3.1

Table 1: Characteristics of the surgical gloves (N=1672)

Characteristic	n	%
Dominant hand		
Right	1597	95.5
Left	75	4.5
Right outer glove perforation		
No	1566	93.7
Yes	106	6.3
Left outer glove perforation		
No	1532	91.6
Yes	139	8.4
Right inner glove perforation		
No	1652	98.8
Yes	20	1.2
Left inner glove perforation		
No	1651	98.7
Yes	21	1.3
Surgery duration		
< 90 minutes	1588	94.9
≥ 90 minutes	84	5.1
Type of surgery		
Bone	1653	98.9
No bone	19	1.1
Surgical team member		
Surgeon	611	36.5
Assistant surgeon	595	35.6
Scrub nurse	466	27.9
Surgical gloves perforation		
No	1386	82.9
Yes	286	17.1

3.2 Anatomical location of occurrence of surgical glove perforation

The most common location of surgical glove perforation was found to be index finger 133 (36.9%), followed by the thumb 76 (21.1%), palm 63 (17.5%), middle finger 58 (16.1%), little finger 19 (5.3%) and ring finger 11 (3.1%) was the least perforated, (see Figure 1).

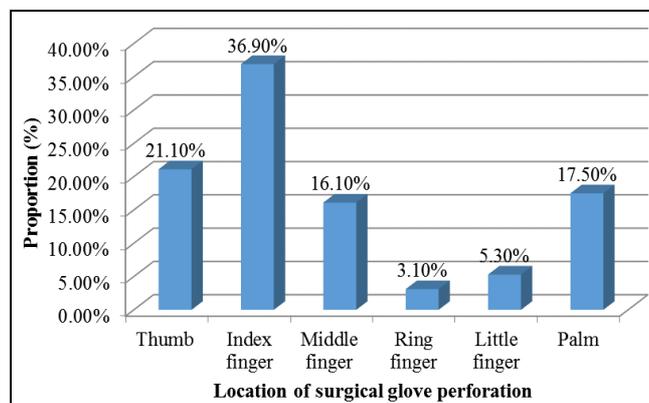


Fig 1: Anatomical location of occurrence of surgical glove perforation (n=360).

3.3 Glove perforation proportion among surgical team members

Of the 286 perforated surgical gloves, nearly half 142 (49.7%) were perforated by surgeons followed by assistant surgeon 102 (35.7%) and scrub nurses 42 (14.6%) were the least, (see Figure 2).

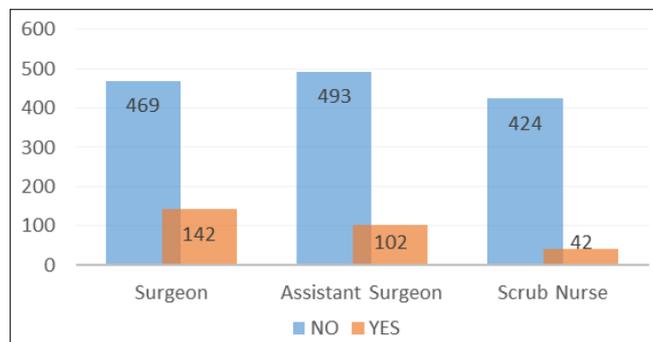


Fig 2: Glove perforation rate among surgical team members, (n=1,672)

3.4 Factors associated with surgical glove perforation

In crude analysis factors such as left dominant hand, surgeries lasting longer than 90 minutes and no bone surgeries type were significantly associated with the surgical gloves perforation. Those participants with left hand domination had approximately 4 times higher odds of surgical gloves perforation compared to those with right hand domination (OR:3.93; 95%CI:2.44-6.34) while assistant surgeon had 32% lesser odds of surgical glove perforation compared to surgeons.

After adjusting for other factors, all factors remained significantly associated with surgical gloves perforation except for assistant surgeon in surgical team members whom they had 18% lesser odds for surgical gloves perforation compared to surgeon (OR: 0.82; 95%CI: 0.59-1.13), eminently bone surgeries had three times more odds of surgical gloves perforation compared to no bone surgeries (OR: 3.09; 95%CI; 1.14-8.38), (see Table 2).

Table 2: Factors associated with surgical glove perforation, (n=1,672)

Factors	Crude			Adjusted		
	OR	(95% CI)	p-value	OR	95% CI	p-value
Dominant hand						
Right	1			1		
Left	3.93	(2.44; 6.34)	<0.001	2.07	(1.15; 3.72)	0.015
Surgery duration						
< 90 minutes	1			1		
≥ 90 minutes	3.49	(1.89; 6.41)	<0.001	3.06	(1.65; 5.67)	<0.001
Type of surgery						
No bony	1			1		
Bony	2.26	(0.85; 6.01)	0.101	3.09	(1.14; 8.38)	0.027
Surgical team member						
Surgeon	1			1		
Assistant surgeon	0.68	(0.51; 0.91)	0.009	0.82	(0.59; 1.13)	0.221
Scrub nurse	0.33	(0.23; 0.47)	<0.001	0.42	(0.28; 0.64)	<0.001

4. Discussion

During orthopaedic surgeries surgical glove perforation is not uncommon as surgical team members are subjected to a range of physical stress such as sharp bony fragments handling, working in deep cavities during hip surgeries in obese patient, rotatory instruments, Kirschner wires and chemical substances such as methyl methacrylate that influence the virtue of surgical glove and argument their rate of perforation

[4].

The results obtained in our study indicated that prevalence surgical glove perforation during elective orthopaedic surgeries has been 17.1% (286), this fall in with approximately the same results found by Pertecke *et al.* (2009) 19% (171) and Ersozlu *et al.* (2007) ^[5,5]. 15.8% (242). Higher rates were found in other studies in which case Bekele *et al.* found a rate of 30% in elective surgeries, The difference between these result may have been attributed to the variation in context as the study was conducted in different specialities hence the circumstances were different ^[6].

Among the surgical team members in our study, surgeons were found to be more prone to surgical glove perforations 49.7% followed by the assistant surgeons 35.7% and finally the scrub nurses 14.6%, this may be accounted by the fact that most of the primary and different manoeuvres such as open reduction of fracture as well as its fixations are done by the surgeons, scrub nurses they were found to have been associating with the decreased odds of surgical gloves perforation (95% CI= 0.28-0.64, $p < 0.01$)

In regard to the surgical glove' anatomical perforation location, several studies have reported that the index finger of the non-dominant hand is the most part of the surgical glove prone to perforation, laine *et al.* (2001) reported left-hand perforation rate of 35.8% (67) followed by left thumb perforation rate of 18.80% (36) ^[7].

This higher perforation rate result in index finger and thumb on the non-dominant hand comply with our study findings in which case the left index finger had perforation of 36.9% (133) followed by left thumb perforation of 21.10% (76).

The highest perforation seen in index finger and thumb of the non-dominant hand in right-handed surgeons could be explained by the mere fact that surgeons are the ones using instruments directly and for longer durations with their non-dominant hand, hold the reduced bone/tissue, course and awkward manipulation while their dominant hand hold instruments that need fine motor coordination.

Literature has shown that double gloving of the surgical glove can reduce their frequency of perforation and hence the adverse aftereffect on both the surgical team members and the patient. Ersozlu *et al.* reported higher perforation rate in outer surgical glove 22.7% as compared to inner glove 3.7% ^[8].

These findings comply with those in our study in which we found higher perforation on outer glove 14.7% as compared to perforation of 2.5% on inner glove, these results in our study reaffirm that double gloving offers significantly better protection than single gloving.

Indeed, the risk of contamination increases with the duration of blood and germs contact to the skin, studies in the literature

⁴ Kaya I, Urafi A A, Sungur I, Yilmaz M, Korkmaz M. and etinus E. (2012) Glove perforation time and frequency in total hip arthroplasty procedures, *Acta Orthopaedica et Traumatologica Turcica*, 46 (1), pp. 57–60. DOI:10.3944/AOTT.2012.2660.

⁵ Ersozlu S, Sahin O, Ozgur A F, Akkaya T. and Tuncay C. (2007) Glove punctures in major and minor orthopaedic surgery with double gloving, *Acta Orthopaedica Belgica*, 73 (6), pp. 760–764.

⁶ Ersozlu S, Sahin O, Ozgur A F, Akkaya T. and Tuncay C. (2007) Glove punctures in major and minor orthopaedic surgery with double gloving, *Acta Orthopaedica Belgica*, 73 (6), pp. 760–764.

⁷ Bekele A, Makonnen N, Tesfaye L. and Taye M. (2017) Incidence and patterns of surgical glove perforations: experience from Addis Ababa, Ethiopia, (March). DOI:10.1186/s12893-017-0228-8.

⁸ Laine T. and Aarnio P. (2001) How often does glove perforation occur in surgery Comparison between single gloves and a double-gloving system, 181, pp. 564–566.

⁹ Ersozlu S, Sahin O, Ozgur A F, Akkaya T. and Tuncay C. (2007) Glove punctures in major and minor orthopaedic surgery with double gloving, *Acta Orthopaedica Belgica*, 73 (6), pp. 760–764.

mention that surgical glove perforation risk increases with the duration of surgery and thus should be readily changed^[9].

Perthecke *et al.* (2009) reported that glove perforation increases with the duration of wear owing to mechanical stress, in their study, perforation was observed in 15.4% of surgical glove in the first 90 minutes of surgeries and this increase to 18.1% if surgical glove was worn between 91-150 minutes and to 23.7% if the surgical glove was worn longer than 150 minutes. (Perthecke *et al.*, 2009)

Similarly, Laine *et al.* (2001) and Egeler *et al.* (2010) concluded that the longer the duration of surgery the greater the possibility of the defect to the surgical glove by a sharp instrument. Al-maiyah *et al.* (2004) show that routine change of surgical gloves during orthopaedic surgeries can significantly reduce the risk of orthopaedic surgical site infection through reduction of unnoticed perforation.

Our findings unveil that as surgery duration increase surgical gloves perforation also increase as it happened significantly more frequent in surgeries that lasted longer than 90 minutes. (95% CI 1.65-5.67, $p < 0.001$). Both of these findings are consistent with the findings in previous reports and therefore based on these findings surgeons and assistant surgeons should look for perforations more carefully during surgery and ensure that proper glove changes are performed.

Finally, the nature and/ or type of surgical procedure may also significantly impact the risk of surgical glove perforation, Thanni *et al.* high rate of surgical glove perforation during bone surgeries (95% CI=1.87-8.55, $P < 0.0001$)^[10].

Our study result confirmed these observations revealing that bone surgeries associated with three times higher odds of surgical glove perforation as compared to soft tissue surgeries (95% CI=1.14-8.38, $P=0.027$).

4.1 Limitations

This study has some limitations. First, Contamination of the perforated surgical glove was not evaluated as our study aim at the mechanical integrity of the glove. Second, ideally all gloves would have been tested immediately after surgery to prevent any post-operative perforation after surgery from occurring, immediate testing was not feasible in our clinical setting; however, precautions were taken to avoid post-operative perforations, these precautions included careful glove handling, storage in plastic containers at room temperatures and testing was done on the same day, and lastly the water leak test is unable to detect surgical glove perforation < 0.5 mm, hence some perforation might have gone undetected.

5. Conclusion

Our study portray that there is a significant relationship between the type of surgery, role of surgical team member, dominance of the hand, glove layer and the location of perforation with the rate of surgical glove perforation.

6. Recommendations

Based on the evidence gathered from our study and in view of the critical importance, to protect surgical team members and likewise patient from blood-borne infection there should be a protocol guideline on intra operative outer glove change for surgeries last longer than 90 minutes.

Although surgical gloves are generally considered a crucial component of universal precaution, these highly regarded

modern medical tools of quality and safety may fail to fulfil their intended purpose, therefore diligence must be given to the early detection of perforation especially to the index finger and thumb during high-risk surgeries such as bone surgeries.

In accordance to their role, surgical team members should become more cognizant of the type and nature of the surgery that associate with the high rate of surgical glove perforation (as highlighted in this study) and take particular precautions.

Further studies are required to find out if surgical glove perforation increases orthopaedic surgical site infection.

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⁹ Choudhari P and Padia D. (2015) Study of Nature of Glove Puncture Injury and its Occurrence in Orthopaedic Surgery, *Indian Journal of Orthopaedics Surgery*, 1 (3), pp. 149. DOI:10.5958/2395-1362.2015.00017.1.

¹⁰ Thanni L O A. (2004) incidence of glove failure during orthopedic operations and the protective effect of double glove (May 2014).