A comparison of the effect of different surgical gloves on objective measurement of fingertip cutaneous sensibility

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ABSTRACT

INTRODUCTION The prudent selection of surgical gloves can deliver significant efficiency savings. However, objective data are lacking to compare differences in cutaneous sensibility between competing gloves. Therefore, the present study examined the use of a single comparable model of sterile surgical glove from two competing providers, Gammex PF HyGrip® (Ansell Limited, Red Bank, NJ, USA) with Biogel® (Mölnlycke Health Care AB, Göteborg, Sweden).

SUBJECTS AND METHODS Cutaneous pressure threshold, static and moving two-point discrimination were measured as indices of objective surgical glove performance in 52 blinded healthcare professionals.

RESULTS The mean cutaneous pressure threshold was 0.0680 ± 0.0923 g for skin, 0.411 ± 0.661 g for Ansell gloves and 0.472 ± 0.768 g for Biogel gloves. Skin was significantly more sensitive than Ansell ($P < 0.0001$) or Biogel ($P < 0.0001$) gloves (Wilcoxon signed rank test). There was no statistical difference between Biogel and Ansell gloves ($P = 0.359$). There was no significant difference between static or moving 2-point discrimination of skin and Ansell gloves ($P = 0.556$, $P = 0.617$; Wilcoxon signed rank test), skin and Biogel gloves ($P = 0.486$, $P = 0.437$; Wilcoxon signed rank test) or Ansell and Biogel gloves ($P = 0.843$, $P = 0.670$; Wilcoxon signed rank test).

CONCLUSIONS No demonstrable objective difference was found between competing gloves in the outcome measures of cutaneous sensibility and two-point discrimination. However, a difference in subjective preference was noted. Untested factors may underlie this discrepancy, and further research should employ more sophisticated measurements of surgical performance using competing models of surgical glove.

KEYWORDS

Surgical glove – Cutaneous sensibility – Discrimination

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In the wake of challenging global economic circumstances, government reforms in nationalised health systems such as the NHS require the delivery of efficient, high-quality services while reducing costs.¹ The careful selection of surgical equipment can deliver significant cost savings; for example, a recent national audit identified that the NHS in Scotland alone spends approximately £2.6 million on surgical gloves per annum.² National procurement directives encouraging open competition between glove suppliers would enable the potential saving of £534,000 per annum.² However, the choice of sterile surgical glove represents a controversial area; although cost savings are possible it is important that surgical technique is not compromised at the expense of patient care. Alterations in surgical glove procurement

which were driven purely by cost without regard for clinical factors have faced wide-spread criticism.³ Nonetheless, there remains a paucity of quantitative evidence to compare the performance of different surgical gloves. Comparative, objective data are required to justify the clinical safety and equality of surgical performance obtained using competing surgical gloves.

A comparison of thin (Biogel Super-Sensitive®) and standard models of the Biogel® glove (Mölnlycke Health Care AB, Göteborg, Sweden) demonstrated a higher level of sensitivity with the thinner model, without statistically significant difference in the resistance to perforation.⁴ Although this study offered a comparison of sensibility with different surgical gloves, only one manufacturer (Mölnlycke Health

Care AB) was tested. An objective comparison of standard surgical gloves from competing manufacturers was not conducted. The effect of double gloving and single gloving on surgeons' ability to tie surgical knots and their two-point discrimination has been assessed,⁵ demonstrating a significant impairment in cutaneous sensibility following double-gloving.

There has been no objective assessment of hand sensitivity between otherwise comparable models of a single, sterile, surgical glove made at variable cost by competing manufacturers. Therefore, the present study examined the effect of a single comparable model of sterile surgical glove from two providers, Gammex PF HyGrip® (Ansell Limited, Red Bank, NJ, USA) with Biogel® (Mölnlycke Health Care AB).

Subjects and Methods

The primary outcome measures of hand sensitivity were cutaneous pressure thresholds, static and moving two-point discrimination. Cutaneous pressure threshold was determined using Touch Test™ Semmes-Weinstein Monofilaments (Richardson Products Inc., IL, USA) shown to be an objective and reproducible way of applying pressure.^{6,7} Static and moving two-point discrimination were determined with the Disk-Criminator® (Richardson Products Inc.).^{4,5,7,8} Previously validated techniques were employed, as described by Novak *et al.*⁹

The data were collected between 1 June 2010 to 01 August 2010. The subjects were staff working at the Chelsea and Westminster Hospital in London. All participants gave informed consent; patients were not involved or affected by the study and, therefore, Local Research and Ethics Committee assessment was waived.

Measurement of fingertip sensitivity

1. Pressure thresholds for cutaneous sensitivity were measured using Touch Test™ Semmes-Weinstein Monofilaments (Richardson Products Inc.) applied to the index finger of non-dominant hand. The monofilaments vary with respect to their diameter, which represents the log₁₀ value of the applied force. The subject's eyes were covered and the monofilament was gently applied to the fingertip pulp, perpendicular to its surface, until the filament bowed. The smallest monofilament to elicit a response was determined by serial testing, with monofilaments of varying sizes applied in a random order determined by a computerised random number generator.
2. The MacKinnon-Dellon Disk-Criminator® (Richardson Products Inc.) was used to assess both static and moving two-point discrimination. The Disk-Criminator® is a plastic disc with pairs of metal prongs around the circumference; each pair is set with a different distance

separating the two prongs. The separation distance of individual pairs of prongs ranged from 8 mm apart to 2 mm apart, each pair varying by a 1 mm increment. Static two-point discrimination was assessed by application of one pair of metal prongs to the fingertip pulp until the subject recognised the stimulus. The process was repeated for each pair in a random sequence and the smallest gap that could be distinguished as two distinct points was recorded. Moving two-point discrimination was assessed by application of the metal prongs to the fingertip pulp so that the stimulus was felt, then the device was moved proximally in a longitudinal fashion. The smallest interval between metal prongs recognised as two distinct points was recorded.⁵

Demographic data

Data on age, profession, hand-dominance, glove size, latex allergy and usual glove preference (Ansell or Biogel) were collected.

Statistical analysis

Cutaneous pressure threshold data for Semmes-Weinstein monofilaments were converted from filament size to the actual pressure delivered in milligrams. Pressure thresholds and two-point discrimination data were compared using the Wilcoxon signed-rank test for each subject's paired values of skin versus Ansell gloves, skin versus Biogel gloves and Ansell gloves versus Biogel gloves.

Results

A total of 52 healthcare professionals (14 surgeons, 25 nurses, 13 physicians or medical students) were tested. The mean age was 33.6 ± 10.4 years and 52% were male. Glove preferences were 4/52 Ansell, 13/52 Biogel, 35/52 no preference.

Cutaneous pressure thresholds

The cutaneous pressure threshold for skin was 0.0680 ± 0.09231 g (mean $\pm$ SD). Cutaneous pressure threshold for Ansell gloves was 0.4107 ± 0.661 g (mean $\pm$ SD) and cutaneous pressure threshold for Biogel gloves was 0.4723 ± 0.768 g (mean $\pm$ SD).

Skin was significantly more sensitive than Ansell ($P < 0.0001$) or Biogel ($P < 0.0001$) gloves (Wilcoxon signed rank test). There was no statistical difference between the cutaneous pressure thresholds of Biogel and Ansell gloves ($P = 0.359$) using Semmes-Weinstein monofilaments.

Static two-point discrimination

There was no significant difference between static two-point discrimination of skin and Ansell gloves ($P = 0.556$; Wilcoxon signed rank test), no significant difference

Figure 1 Static two-point discrimination with different models of surgical glove.

between static 2-point discrimination of skin and Biogel gloves ($P = 0.486$; Wilcoxon signed rank test) and no significant difference between static 2-point discrimination of Ansell gloves and Biogel gloves ($P = 0.843$; Wilcoxon signed rank test; Fig. 1).

Moving two-point discrimination

There was no significant difference between moving 2-point discrimination of skin and Ansell gloves ($P = 0.617$; Wilcoxon signed rank test), no significant difference between moving 2-point discrimination of skin and Biogel gloves ($P = 0.437$; Wilcoxon signed rank test) and no significant difference between static 2-point discrimination of Ansell gloves and Biogel gloves ($P = 0.670$; Wilcoxon signed rank test; Fig. 2).

Discussion

The aim of this study was to provide objective assessment of hand sensitivity and discrimination between comparable single models of sterile surgical glove made at variable cost by competing manufacturers. Two alternative gloves were compared; Gammex PF HyGrip® and Gammex PF Sensitive® with Biogel® glove and Biogel Skinsense®. A mixed multidisciplinary team was used as test subjects, to minimise the potential for bias introduced by surgeons who may have been able to recognise their preferred glove whilst blind-folded. Cutaneous pressure threshold analysis revealed skin was significantly more sensitive than both gloves, but there was no difference between the Biogel and Ansell gloves. Tests of static and moving 2-point discrimination revealed no significant difference between skin or either glove. Therefore, in the primary outcome measures assessed, the performance of these two surgical gloves was similar. Furthermore, it was not possible to demonstrate a deficit with either glove compared to ungloved skin in terms of 2-point discrimination (static and moving). This

Figure 2 Moving two-point discrimination with different models of surgical glove.

demonstrates high levels of tactile feedback available using modern glove technology.

Cutaneous pressure threshold was better for skin than for either of the two glove types tested. Deficits in cutaneous pressure threshold could be a risk factor in glove perforation, which has become an area of concern as a number of blood-borne pathogens pose a significant risk to the health of operating surgeons.¹⁰ In many different specialities, surgeons have advocated using double gloving techniques to limit the danger posed by glove perforation and blood-borne pathogens.^{11–15} The safety advantages incurred are offset by presumed disadvantages including reduced manual dexterity and tactile sensation.¹⁴ However, these disadvantages have been the subject of much debate with a recent paper by Fry *et al.*¹⁵ failing to show any significant differences in manual dexterity or tactile sensation associated with double gloving. The merits and disadvantages of double gloving were not the focus of the present study. However, the relative risk of single glove perforation with competing surgical gloves requires further study. It is likely that this represents one of the many factors differentiating the alternative gloves in the present study that were not analysed. In addition to cutaneous sensibility and resistance to perforation, other glove characteristics require objective assessment and correlation with surgeon preference, such as grip strength. Such factors are likely to underlie the discrepancy in glove preference seen amongst study subjects despite the lack of a demonstrable difference in the studied outcome measures of cutaneous sensibility or two-point discrimination.

Currently, Biogel gloves are more expensive than the Ansell gloves used in this analysis (£1.11 per glove versus £0.71 per glove, personal communication). For a box of standard surgical gloves as used in the present study, the Biogel model is almost twice the cost of the Ansell model (£55.55 versus £28.34). This represents an important economic consideration, as there was no demonstrable difference

between the two glove types in the studied outcome measures. However, the views of surgeons and theatre staff must be taken into account prior to purchasing surgical gloves, and the study revealed a clear discrepancy in favour of the more expensive Biogel model. It is likely that more subtle indices of performance are required to investigate objective differences in performance that underlie the subjective prejudice between these models of glove. Future studies should, therefore, focus on assessment of composite surgical skills rather than isolated measures of sensitivity, to assess the economy of movement and efficiency of operative tasks performed using competing gloves. Validated operative simulation techniques have been used to generate objective measures of surgical proficiency;¹⁶ the use of these methods may offer a more sophisticated measurement tool for the appraisal of competing surgical gloves. Further research should seek to address this weakness of the present study, which employed relatively crude outcome measures that may not accurately reflect differences underlying the discrepancy in surgeons' preferences between surgical gloves.

Nonetheless, the present study provides the first objective assessment of hand sensitivity between otherwise comparable models of sterile surgical glove made at variable cost by competing manufacturers. The choice of surgical glove remains a balance between cost and clinician preference. Objective data are required to ensure that improvements in cost-efficiency through the use of inexpensive surgical gloves do not compromise patient care through the provision of technically inferior equipment and disregard for clinician preference.

Conclusions

No demonstrable objective difference was found between competing gloves in the outcome measures of cutaneous sensibility and two-point discrimination. However, a difference in subjective preference was noted. Subjective preference is clearly an important factor, which must be taken into account when deciding on bulk purchasing. Untested factors are likely to underlie this discrepancy, and investigation of a wider range of outcome measures is required to analyse differences between surgical gloves, as measures of

cutaneous sensibility alone may not limit surgical performance. Further study is needed to identify more complex objective differences in performance between competing surgical gloves, to ensure cost-savings are not delivered at the expense of patient care.

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