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Major article

A study of clinicians' views on medical gloves and their effect on manual performance

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Latex
Nitrile
Fit

Background: The effect of gloves on practitioners' performance has not been a major factor in their design. To determine the critical elements of performance and design appropriate tests, data from clinicians were needed.
Methods: Semistructured interviews were carried out with medical practitioners from various disciplines, in which they were asked about their glove use, their views on gloves, medical tasks requiring the highest manual performance or most affected by gloves, and what the main issues with glove use were.
Results: Many participants expressed a preference for latex over nitrile, with glove fit being the main reason given. Satisfaction with surgical gloves (generally latex) was high but less so with examination gloves, which were generally nitrile. Tactile sensation, comfort, and donning were also seen as major issues with glove use. A number of tasks were identified for possible development as tests.
Conclusion: Performance in medical practice needs to be clearly defined, separating perceived and measured performance, and understanding the effect of glove material, fit, and thickness. Development of new glove performance tests based on the tasks identified is an important part of this.

Broadly speaking, there are 2 types of medical gloves: examination gloves, which are ambidextrous, usually nonsterile, and come in a small range of sizes, are used for nonsterile and less dextrous tasks and also for most dental work; surgical gloves are sterile, come individually packaged in handed pairs, and are usually available in half-inch intervals of hand girth. They are used in the operating theater for a variety of dextrous tasks, ranging from microsurgery on the eye or ear to bone setting or hip replacement.

Because the majority of clinical work is not perceived to be as dextrous as surgery, less emphasis is placed on the performance of examination gloves. Until recently, both examination and surgical gloves were generally made from natural rubber latex (commonly referred to as "latex"), although alternatives were available for known cases of latex allergy. However, the lack of regulation of manufacturing processes in the early years of mass production meant that gloves often contained a high level of allergenic proteins, which led to a steady increase in the number of cases of latex allergy reported.[1]

Current guidelines from the National Health Service and the Royal College of Physicians[2] in the United Kingdom state that "the evidence does not … support a need to ban latex completely from the workplace." They note that nonlatex surgical gloves "have higher failure rates in use and lower user satisfaction than latex gloves." Instead, they advocate the use of nonpowdered, low-protein latex gloves, except for employees with latex allergy, latex sensitization, or latex-induced asthma, where nonlatex alternatives are recommended. However, most primary care health care groups and hospitals in the United Kingdom have replaced latex in nonsurgical situations with less flexible alternatives[3] such as nitrile to remove the risk of latex allergy in patients and practitioners.

Similarly, the American College of Allergy, Asthma, and Immunology[4] recommends that "a facility-wide review of glove usage should be undertaken to determine the appropriateness of use … and thereby prevent the unnecessary use of latex gloves" and advocates nonpowdered, low-protein gloves as standard in a health

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care facility but also states that "hospitals need to evaluate manufacturer information on nonlatex gloves in areas of durability, barrier protection, and cost" because "latex is still considered superior with respect to barrier characteristics against transmissible diseases." Surgeons have generally resisted moves to replace surgical gloves in the same way because of the perceived reduction in manual performance when using nonlatex alternatives.

With respect to the glove design process, there is little or no evidence that gloves are evaluated in terms of their effects on users' manual performance. All the currently available standards[5,6] focus on the barrier integrity of the gloves by defining tensile strength, freedom from holes, and tear resistance. Similarly, much of the research on medical gloves has concerned barrier integrity[7,8] and adherence of practitioners to handwashing and glove handling guidelines.[9,10] Clearly, because the primary role of the gloves is to prevent the spread of infection, it is important that the design brief takes these things into consideration, but achieving good barrier integrity is not necessarily incompatible with achieving the best performance.

Glove performance also has an effect on safety, particularly in a surgical environment. Surgeons using gloves with less-than-optimal frictional properties, for example, may be more likely to drop instruments, to slip when performing delicate procedures, or to increase their stress levels when attempting to compensate. Similarly, practitioners who cannot feel a pulse through gloves when taking blood will be more likely to remove the gloves and increase their risk of infection. A 1994 survey of health care workers[11] found that a "perceived interference with technical skills" was a common obstacle to compliance with universal precautions. There is also a subjective element to the performance that must be considered, which is that practitioners' comfort and confidence in their gloves may affect their concentration levels and therefore their ability to perform surgery over extended periods of time.

It is vital that the glove design process includes an assessment of their effect on manual performance to ensure that practitioners can operate safely and efficiently. The first step in this process is to determine the key aspects of manual performance in medical practice and where current gloves have a significant adverse effect. The second is to design tests that are useful predictors of clinical performance. It is therefore necessary to identify the tasks that are most challenging and on which gloves are thought to have the greatest impact so that the tests can be designed to simulate relevant manual skills.

To achieve this, semistructured interviews with medical practitioners were carried out. As well as gathering information on the participants' roles, disciplines, and glove use, a series of open-ended questions were used to identify tasks believed by users to require the most dexterity and tactility, and those most affected by glove performance, as well as any other issues related to gloves that might aid the study. The interviews took place within Sheffield Teaching Hospitals NHS Foundation Trust (STH) and received ethical approval from the research ethics committees of STH and The University of Sheffield, UK.

Focus groups were considered as a means of gathering data fairly quickly and stimulating discussion. However, the limited availability, particularly of senior staff, made this a difficult approach. Furthermore, it has been shown[12] that, when recruitment, transcription, and analysis are included, focus groups can be much more time-consuming than individual interviews. Although focus groups are generally accepted to produce a wider range of responses, this is not always the case and depends on the nature of the questions.[12,13] In this study, many of the questions were of a technical nature and specific to the individual's specialty. There was also a concern that participants' opinions on specific gloves would be influenced by those of their colleagues.

Interviews were therefore conducted on a one-to-one basis to increase flexibility and enable senior staff to participate at their own convenience, often between operations or appointments. The questions were designed to be sufficiently open-ended so that the participant was not led down one particular line of thought but also included prompts where information was not forthcoming. With a wide enough selection of participants, it was hoped that a consensus would be formed in at least some of the areas, which would enable judgments to be made on the most productive direction for future research.

METHODS

Participants were approached by e-mail, and interviews were conducted at their place of work. The duration of the interviews varied between 6 and 28 minutes. Audio from the interviews was recorded and transcribed at a later date.

An interview guide was created for the study. Participants were asked about the following:

- Their examination glove use and surgical glove use: frequency, current type(s) used, preferences, activities for which they are used, grasp types used (Cutkosky's taxonomy of grasp types[14] was used as a guide [see Fig 1]);
- tasks requiring most manual dexterity, tactile sensation, and hand fatigue and those most affected by wearing gloves tasks most likely to cause tearing;
- what they considered to be the main issues with glove use;
- their perception of how various glove properties affect performance;
- special precautions regarding glove use when risk of infection is high; and
- other issues or incidents that would be helpful to know.

Participants from a range of disciplines and roles were included so that there was a better chance of determining the particular areas where the use of gloves causes difficulty. It was also desirable to have a range of experience in the practitioners because those with a lot of experience may have different issues with gloves and find different tasks harder. Preference for glove type was also expected to vary because it was thought that the conditions in which practitioners train have an effect on their future preference.

No fixed sample size was set because recruitment was constrained by time and availability of participants, and more participants were recruited in those areas that yielded more useful data as the study progressed. For example, there was a much broader range of tasks and opinions among orthopedic surgeons than among anesthetists. Thirty-five medical practitioners were eventually interviewed. Table 1 shows a breakdown of the participants by discipline and position.

RESULTS

Results are displayed in terms of percentage of users who gave each response. However, it should be noted that, because of the informal nature of the interviews, not every participant answered every question, and some responses covered a number of points. Therefore, the percentages will not add up to 100, but give an indication of the relative frequency and importance of responses.

Examination gloves

Examination gloves were used for a variety of tasks including performing examinations, using power tools such as a dental hand piece (eg, for drilling) and precision tools such as forceps (eg, for

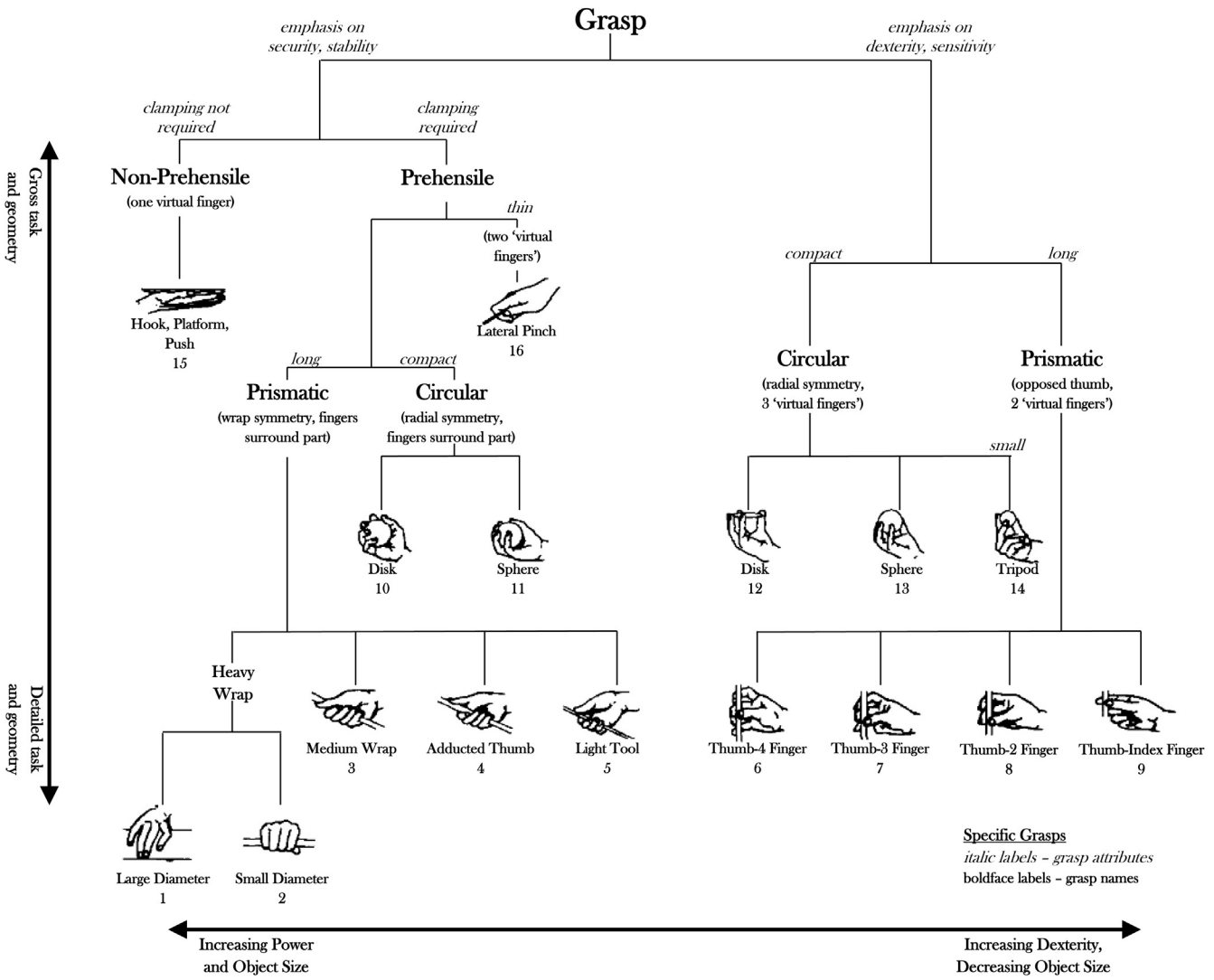

Fig 1. Taxonomy of grasps, modified from Cutkosky and Wright, 1986.[14]

Table 1
Breakdown of interview participants

Discipline	Consultants (7)	Registrars (4)	Senior house officers (1)	Nurses/other
General surgery (colorectal)	3	2		2
Cardiology		1		
Orthopedics	5	1	1	2
Ophthalmology	1	2		
Urogynecology	1	1		
Dentistry	2	2		1
Anesthetics	3			1
Phlebotomy				1
Transplant	1			
Emergency	1			
Ear, nose, and throat	1			

NOTE. Minimum experience in years is shown in parentheses in headings.

removing stitches), taking blood and cannulating, applying dressings, and cleaning. A broad range of grasps were used, particularly precision prismatic grasps (see Fig 1). Most users found it difficult to define exact grasps, particularly in relation to Cutkosky's diagram, so exact numbers were hard to obtain. The fact that many medical tasks use tool-specific grasps that do not fit into conventional categories may be relevant when selecting and designing grasping and dexterity tests, most of which are based around standard prismatic grasps.

Thirty-four of the 35 participants used examination gloves regularly, usually multiple pairs daily. All of those used Schottlander Latex-Free Flexible Nitrile gloves (Davis Schottlander & Davis Ltd, Letchworth, UK) within STH as were mandated by the Trust, although many had previous experience of latex or copolymer gloves (a blend of 2 polymers, such as polyethylene and ethylene butyl acrylate). Only the ophthalmic surgeon did not use them at all. Some also used Bodyguards Sterile Blue Nitrile Exam Gloves (BM Polyco Ltd, Enfield, UK) for sterile dressings, and some used Sterling Nitrile Gloves (Kimberly-Clark Ltd, Kings Hill, UK) within another primary care health care group at which they worked part-time.

Table 2 shows user opinions on examination gloves, including material preferences and issues with their current nitrile gloves. When asked whether they would use a different type of examination glove if they had the choice and allergy was not an issue, many participants made comparisons with previously used latex gloves. Almost half of participants expressed a preference for latex over the current nitrile ones, with many saying that they fitted or conformed better. Easier donning, better comfort, and greater roughness (leading to a perceived increase in grip) were also given

Table 2
Examination glove-related responses of 34 regular users

Examination glove preferences			Issues with current nitrile gloves		
Response	No.	% Of respondents	Response	No.	% Of respondents
Prefer L to current N	16	47.1	Fit	11	32.4
L fit better than N	8	23.5	Elasticity	7	20.6
Prefer current N to copolymer	3	8.8	Loss of tactility	6	17.6
L easier to don than N	3	8.8	Donning	5	14.7
L more comfortable than N	2	5.9	Dermatitis	2	5.9
Prefer roughness of L	1	2.9	Surface roughness	2	5.9
No preference for L or N	7	20.6	Comfort	2	5.9
			Tearing	2	5.9
			Generally happy	5	14.7

L, latex; *N*, nitrile.

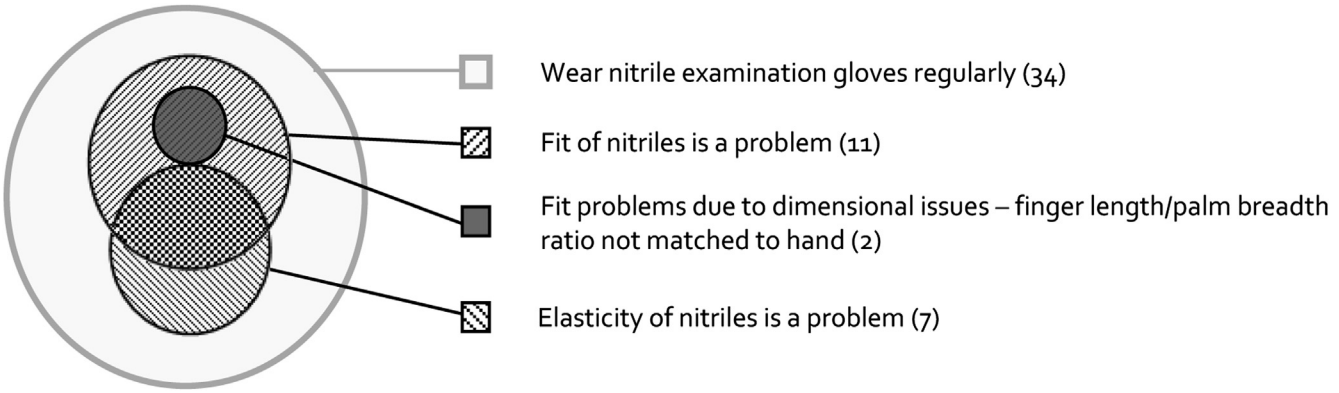

Fig 2. Venn diagram of fit-related responses (number of responses in parentheses).

as reasons for the preference. Whereas some users expressly stated that they did not have a preference for latex or nitrile, none expressed a preference for the nitrile over the latex (besides reasons of allergy).

Fit of the currently used nitrile gloves was identified as a problem by almost one-third of regular glove users and was followed by elasticity, with loss of tactility and difficulty with donning also relatively significant issues. Figure 2 shows the interaction of responses, the area of each circle being proportional to the number of responses that fitted that group, and the overlapping areas representing those whose response fitted more than 1 group.

A number of users identified fit and elasticity together as problems with nitrile gloves, suggesting a perceived link between the 2. All of those participants were among those who thought that latex, a more elastic material, fitted or conformed better. An alternative explanation given for fit problems was the mismatching of glove and hand dimensions and ratios. Loss of dexterity and tactile sensation were identified as the main effects of poor fit.

Surgical gloves

Surgical gloves were used less regularly but usually a few times a week. Dentists and non-theater nurses tended to use them less than once a week or not at all. Most used Biogel standard latex gloves (Mölnlycke Health Care, Gothenburg, Sweden). Orthopedic surgeons also used indicator under-gloves (green-colored gloves that help to identify punctures in surgical gloves), except for surgery on hands, which requires finer dexterity. Some general and orthopedic surgeons also used a latex glove with a nitrile coating. Ophthalmologists used Biogel M, a microsurgery latex glove, and 2 participants used Biogel Super-Sensitive, a thinner glove. Nonlatex options included polychloroprene (neoprene) and polyisoprene, but these were generally used only in cases of known patient or surgeon allergy.

None of those who used surgical gloves expressed a desire to change (except for reasons of allergy), with the majority explicitly stating that they were happy with their current Biogel gloves. Some mentioned reasons for this such as comfort, tear resistance, fit, sensitivity, and flexibility. There was, however, a general openness to alternatives if it saved money, provided they were of equivalent or better quality.

Eight participants had used latex alternatives, and 6 mentioned using nonlatex alternatives. All of those preferred Biogel, except 1 who could not remember a difference. Complaints for latex alternatives included feeling thicker (although they were not, according to manufacturers' data and laboratory measurements), less sensitive, less comfortable, and less flexible, not fitting as well, and being more slippery; the nonlatex gloves were perceived to be "stiffer" and therefore less sensitive, slippery, and hard to don but primarily that they did not "feel right" or the "handling" was not as nice. Most participants chose not to wear the Biogel Super-Sensitive gloves because they either tore more frequently or caused them to worry about tearing.

Tasks carried out using surgical gloves were generally more dextrous and specific to the specialty, varying from microsurgery in the eye with delicate hand tools to using power tools and bone mallets in orthopedics. Common tasks included incision with a scalpel, retracting, instrument and tissue handling, suturing, and knot tying.

Tasks

The tasks most commonly identified by practitioners as being adversely affected by gloves involved feeling blood vessels: cannulating, injections, taking blood, or measuring a pulse. Knot tying

and suturing, handling syringes and vials, using adhesive tape or dressings, and per rectal examination were also common. The requirements of these tasks include fine dexterity, such as manipulating tools and small objects, and tactility, such as the identification of surface irregularities with fingertips. A comment made by 7 participants was that you get used to wearing the gloves and adapt your technique, or your brain modifies the way it interprets sensory information to compensate for the gloves.

Other tasks identified as requiring manual dexterity include using a scalpel to make an incision, manipulating prostheses and fractures, laparoscopic surgery, and endoscopy. The required dexterity ranges from very fine (eg, using an ophthalmic chopper to manipulate the lens during cataract surgery) to coarse (removing Ilizarov frames with spanners).

Tactility was commonly linked to dexterity in terms of feedback when manipulating tools (eg, dental hand piece, orthopedic power tools). Other tasks identified as requiring tactility included feeling soft-tissue properties (tension, lesions) and fracture fragments and applying Vacuum Assisted Closure dressings (KCI, San Antonio, TX).

Hand fatigue

Almost one-third (31%) of the 35 participants rarely or never experienced hand fatigue. Only 1 participant thought that their current glove type and size contributed to fatigue, but 6 (17%) thought that wearing tighter gloves might increase fatigue, whereas another 6 thought that glove size was irrelevant.

Other reasons given for hand fatigue in surgery included excessive physical exertion, length of the operation, or position involved. One ophthalmologist said that psychological stress could be a factor in fatigue, causing you to grip more tightly, and that reducing fatigue was down to technique and learning to relax. The most common tasks that were mentioned as causing hand fatigue were laparoscopic surgery, retracting, using rotating, trigger-operated tools (dentists and orthopedic surgeons), and suturing.

Tearing

By far the most common reason given for tearing was donning, especially if hands are not completely dry. The increase in friction with damp hands means that excessive force is required to pull them on, often causing the cuff to break. Orthopedic surgeons, who double-glove because tearing is a particular issue for them, found bone fragments to be the most common cause, whereas 2 colorectal surgeons also found cutting or piercing of the nondominant hand during suturing or cutting to be fairly common. Sterile gloves were perceived by some participants to tear more than examination gloves.

Main issues with glove use

Participants were asked the question, "What are the main issues with glove use?" As with all of the questions, responses were free and not limited to a predetermined list of options. All participants provided a response to this question.

The main issue with glove use was most commonly identified as tactile sensation (23% of participants). Gloves were thought to reduce sensation, particularly when fit was poor. Some participants said that, if gloves gave the same sensation as bare hands, they would be more likely to wear them for certain tasks such as cannulating. Fit was mentioned by 20% of participants, either the importance of it in terms of performance, the poor fit of the nitrile gloves because of lack of flexibility, wrongly dimensioned gloves, or manufacturing variations.

Table 3
Most common responses concerning the effects of glove properties on performance

Response	No.	% Of respondents
Material (35 respondents)		
Prefer L to alternatives	16	45.7
L more elastic/flexible than alternatives	11	31.4
Tactile sensation of L better than alternatives	6	17.1
N does not fit well	6	17.1
L conforms better than alternatives	3	8.6
L more comfortable than alternatives	2	5.7
Grip pattern (22 respondents)		
Nitrile examination gloves		
Had not noticed grip pattern	9	40.9
Had noticed but no opinion	4	18.2
Improves performance	3	13.6
No difference in performance	2	9.1
Surgical gloves		
Noted rough finish on Biogel	5	22.7
Roughness improves grip	3	13.6
Thickness (28 respondents)		
Linked to cutaneous sensibility or feel	19	67.8
Choose not to use thinner gloves because of actual or potential tearing	7	25
Inverse relationship with dexterity	4	14.3
No effect on performance	3	10.7
Negligible effect on performance	2	7.1
No effect unless very thick	2	7.1
Fit (35 respondents)		
Oversized gloves		
Loss of sensibility	11	31.4
Flap about or get caught	4	11.4
Reduce grip	3	8.6
Undersized gloves		
Uncomfortable	6	17.1
Increase fatigue	5	14.3
Restrictive	3	8.6

L, Latex; *N*, nitrile.
NOTE. Responses are grouped according to the glove property to which they refer (Material, Grip pattern, Thickness, and Fit).

Comfort of the gloves, most often related to sweating and clamminess, was an equally common response. Eleven percent of the participants thought that donning was the main issue, with most of those particularly focusing on donning when hands are not completely dry. The problem was not confined to examination gloves but also included surgical and microsurgical gloves.

Other common issues included restriction of movement and poor flexibility of the nitrile examination gloves and the need for better grip. Two participants said they would like the gloves to be both stronger (to give puncture resistance) and thinner (to give better tactile sensation and dexterity). Irritation of the skin, lack of good alternatives to latex, need to improve the indicator system, and problems with the aramid safety gloves (used for puncture protection when there is a high risk of infection) were also mentioned.

Effect of glove properties on performance

Participants were asked to discuss the effect of glove properties on performance. These properties were separated into 4 categories: material, thickness, grip pattern, and fit. Not all participants discussed every category, and many responses did not directly discuss the relationship between properties and performance. The most common responses are listed in Table 3.

Material

Latex is clearly the preferred material among medical practitioners, and the responses suggest it is mainly due to better flexibility and conformability, which was perceived as fitting better. The main effect of this was thought to be on tactile sensation. Nonlatex gloves were often perceived to be thicker even when they were not, and this was also thought to affect

tactility. It is possible that there was a genuine reduction in thickness in the latex gloves when stretched, given their greater flexibility.

In terms of material effect on performance, responses were mixed between those who thought it impacted performance and those who did not. Of those who thought it did, reasons included that the inelasticity of nonlatex gloves—causing poor fit—made them unsafe and that performance was slowed by needing to replace gloves that tear constantly. Of those who thought that material had no effect, many thought that adaptation to the gloves minimized any loss in performance.

Thickness

Thickness was linked to cutaneous sensibility or feel by two-thirds of those who responded, whereas some perceived an effect on dexterity. Many recognized that there was a trade-off between tear resistance and sensitivity, but the relative importance of each depended on the role of the respondent: 2 orthopedic surgeons and 2 general surgeons said they would prioritize puncture resistance over sensitivity, whereas 1 dentist, the ear/nose/throat surgeon, and the transplant surgeon said the opposite. Worrying about tearing was also a factor as much as the problem of tearing itself.

A number of participants said that they chose not to wear the Super-Sensitive gloves, either because they tear, they worry about tearing, they did not perceive a performance increase, or they were too expensive. Only 2 participants did use them, and one of those only when double gloving for intricate surgery.

Whereas many participants linked glove thickness with cutaneous sensibility and dexterity, most were less able to define the specific effect of thickness on their performance. Of those who directly addressed the link (29%), the majority (20%) thought that thickness had little or no effect on their actual performance. Thicker gloves were thought by some to increase the risk of dropping instruments or cutting oneself or more generally to make precision tasks harder.

Grip pattern

Many medical gloves (including the examination gloves used by STH staff) have a raised pattern on the fingertips that aims to improve grip. Those participants who showed more of an interest in discussing glove properties and their effects on performance were asked their opinions on the effects of the grip pattern. Almost half of respondents had not even noticed the printed pattern on their examination gloves, and most did not have a clear idea of what the grip pattern was supposed to achieve. It was assumed, by those who had noticed it and those who had not, that the pattern was either to improve tactility or grip, and the perception of its success in either of those was mixed. The rough finish on Biogel surgical gloves was noted by 5 respondents, with 3 of those believing that it improved grip.

Fit

Oversized and undersized gloves produce different issues and so are treated separately. The most common comment on sizing was that, to have the correct palm breadth, participants often had to use gloves where the finger length or breadth was not correct. Those who had short fingers were having to pull the gloves up regularly. On the whole, people had an issue with fingers being too loose or baggy, as opposed to palms, which people preferred to be loose to allow movement and palm contact. Four people specifically said that they preferred snug-fitting gloves or deliberately under-gloved (went down half a size), 2 saying it was for better feel; 1 participant wore loose gloves to reduce sweating.

A number of people said that they were between sizes on the nitrile gloves or that the gloves did not fit at all and that the much larger range of surgical glove sizes made it easier to find a glove that fits and therefore to do fine tasks such as incising. Some participants also noted that they have to go up a size if their hands are not dry after scrubbing or at the end of a surgical list, when their hands have swelled.

Special precautions for situations with a high risk of infection

Forty-nine percent of those interviewed said that they double gloved for high-risk patients: 1 wore indicator under-gloves. More than half of those commented that tactile sensation was worse. Theater nurses said they also could not feel the temperature of water or pick up sutures. Other comments were that they were restrictive, made you feel clumsier, slowed you down, or were uncomfortable or even painful (for 1 participant who found the gloves too small already). However, most said, when asked, that they could still perform the tasks as required. One participant said that he thought the loss of sensation was due to the movement between the layers inhibiting transmission of sensation, rather than the increased thickness, so that active touch was most affected.

All but one of the orthopedic surgeons, who always double gloved in theatre, wear aramid under-gloves for high-risk patients. The hand surgeon used them once but found that they reduced sensation, making you too "clumsy," increasing the risk of injury, and said that good practice and not rushing is a better way to protect yourself. Other surgeons had also used them previously. Those who had used the aramid under-gloves were very critical of them, saying they were restrictive. However, most said that you could adapt and do most basic tasks even if it took longer, with only 1 saying it made suturing impossible.

Thirty-one percent of participants said that they did not double glove. Most said they always used "Universal Precautions," some commenting that they believed the loss of sensation caused by double gloving increased the risk of injury and that 2 layers were not enough to prevent injury anyway.

Miscellaneous comments

Because of the informal nature of the interviews, views on a number of other topics were recorded. These included glove requirements, getting used to gloves, cost and quality, lubrication and wet grip, provision of gloves and glove sizes, other types of gloves (eg, indicators, obstetric gauntlets), gender differences, powdered gloves, and using gloves as a tourniquet.

DISCUSSION

A broad range of tasks are performed with examination gloves, using many different grasp types. Although all participants used nitrile examination gloves at the time of participation, many expressed a preference for latex, with the main reason being a perception that they fit or conformed better. Loss of cutaneous sensibility was also identified as a common issue.

Surgical gloves are used less regularly, generally for more dextrous and more specialized tasks. Most clinicians used latex gloves and expressed overall satisfaction with them. Nonlatex gloves were generally used only in cases of known allergy and were less satisfactory.

In those tasks perceived to be most adversely affected by gloves, the main performance requirements were fine dexterity and tactility. The 2 were also linked in terms of tactile feedback when manipulating tools.

The main issues with gloves identified by participants were tactile sensation, fit, comfort, and donning. Reduction in tactile

sensation was often linked to fit and was identified as a reason why gloves were not worn for some tasks such as cannulating. Minimizing the effect of medical gloves on tactile sensation is therefore critical to ensuring compliance with universal precautions and hence reducing the spread of infection. Hand fatigue was not generally thought to be affected by gloves, and glove tearing was only a major issue for the orthopedic surgeons (hence their double gloving).

Most practitioners had opinions and preferences with regard to glove material, but opinion was divided on whether performance was actually affected or whether practitioners adapted to the gloves. Those who did identify performance differences commonly named inelasticity (causing poor fit and thus reducing safety) and poor tear resistance (causing time loss in replacing gloves) as the main performance issues.

Participants identified a clear link between thickness and perceived cutaneous sensibility, but the effect of thickness on performance was much less clearly defined. Grip pattern was not generally perceived to have an effect on performance. Fit, however, was seen as contributing to a number of issues, with loose gloves causing loss of sensation, reducing grip, or obstructing, and tight gloves increased discomfort and fatigue and restricted movement. The limited sizes and shapes of the gloves were often a problem, particularly with the nitrile examination gloves. Most of the participants used a double layer of gloves for high-risk surgery, and many found this to reduce tactile sensation, although most said they could still perform the tasks they were required to do.

From the results of the study, a number of key areas for further research were identified: defining performance in medical practice and understanding how gloves affect it; separating and comparing the perceived effects from the measurable ones; understanding the effect of glove material (particularly elasticity and grip) on performance and the differences between latex and nonlatex (particularly nitrile) examination gloves; the effect of glove fit on both tactility and dexterity; and the effect of glove thickness on tactility.

As well as determining the direction of future medical glove research, the study has identified a number of dexterity- and cutaneous sensibility-critical tasks across the range of medical disciplines. It is clear that manual performance should be a major consideration in both medical glove design and procurement and that, because not all disciplines or tasks require the same performance, there may be a need for a broader range of products. Some of the tasks identified, along with a methodologic review, eg, Mylon et al,[15] may form a basis for the selection of appropriate tests and development of new tests through which medical gloves can be evaluated and their effects on manual performance more clearly understood. Gloves that are designed for better manual performance will ultimately increase safety by reducing surgical errors and increasing compliance with universal precautions.

References

1. Latex and you. Health and safety executive (UK); 2000 (cited April 17, 2013). Available from: http://www.hse.gov.uk/pubns/indg320.pdf. Accessed April 17, 2013.
2. NHS Plus (UK); Royal College of Physicians (UK); Faculty of Occupational Medicine (UK). Latex allergy: occupational aspects of management. A national guideline. London: RCP; 2008.
3. NPSA. Report of a survey of the responses of NHS organisations to the risks of patient and staff sensitivity to natural rubber latex. London: National Patient Safety Agency; 2004.
4. Sussman G, Gold M. Guidelines for the management of latex allergies and safe latex use in healthcare facilities. Arlington Heights [IL]: ACAAI; 1996.
5. British Standards Institution. Medical gloves for single use part 2: requirements and testing for physical properties. BS EN 455-2:2009+A2:2013. London: BSI; 2009.
6. British Standards Institution. Protective gloves against mechanical risks. BS EN 388:2003. London: BSI; 2003.
7. Korniewicz DM, El-Masri M, Broyles JM, Martin CD, O'Connell KP. Performance of latex and nonlatex medical examination gloves during simulated use. Am J Infect Control 2002;30:133-8.
8. Rego A, Roley L. In-use barrier integrity of gloves: latex and nitrile superior to vinyl. Am J Infect Control 1999;27:405-10.
9. Godin G, Naccache H, Fortin C. Understanding physicians' intention to use a simple infection control measure: wearing gloves. Am J Infect Control 1998;26:413-7.
10. Lund S, Jackson J, Leggett J, Hales L, Dworkin R, Gilbert D. Reality of glove use and handwashing in a community hospital. Am J Infect Control 1994;22:352-7.
11. Williams COB, Campbell S, Henry K, Collier P. Variables influencing worker compliance with universal precautions in the emergency department. Am J Infect Control 1994;22:138-48.
12. Coenen M, Stamm TA, Stucki G, Cieza A. Individual interviews and focus groups in patients with rheumatoid arthritis: a comparison of two qualitative methods. Qual Life Res 2012;21:359-70.
13. Rat AC, Pouchot J, Guillemin F, Baumann M, Retel-Rude N, Spitz E, et al. Content of quality-of-life instruments is affected by item-generation methods. Int J Qual Health Care 2007;19:390-8.
14. Cutkosky MR. On grasp choice, grasp models, and the design of hands for manufacturing tasks. IEEE Trans Robot Autom 1989;5:269-79.
15. Mylon P, Carré MJ, Lewis R, Martin N. Review of test methods relevant to medical glove design. Proceedings of the 55th Human Factors and Ergonomics Society Annual Meeting. Las Vegas [NV]: Human Factors and Ergonomics Society; 2011. p. 700-4.