Protective gloves for use in high-risk patients: how much do they affect the dexterity of the surgeon?

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Twenty-five orthopaedic surgeons underwent eight motor and sensory tests while using four different glove combinations and without gloves. As well as single and double latex, surgeons wore a simple Kevlar® glove with latex inside and outside and then wore a Kevlar and Medak® glove with latex inside and outside, as recommended by the manufacturers. The effect of learning with each sequence was neutralised by randomising the glove order. The time taken to complete each test was recorded and, where appropriate, error rates were noted.

Simple sensory tests took progressively longer to perform so that using the thickest glove combination led to the completion times being doubled. Error rates increased significantly. Tests of stereognosis also took longer and use of the thickest glove combination caused these tests to take three times as long on average. Error rates again increased significantly. However, prolongation of motor tasks was less marked. We conclude that, armed with this quantitative analysis of sensitivity and dexterity impairment, surgeons can judge the relative difficulties that may be incurred as a result of wearing the gloves against the benefits that they offer in protection.

The increasing risk of blood-borne viral contamination of health workers and surgeons in particular has led to several studies into the effect of increasing the thickness of surgical gloves on their ability to allow organisms to penetrate them *(1,2)*.

Our objective was to test our hypothesis that these gloves would impair sensory and motor performance and to analyse the extent to which the various modalities are affected. The outcome of this study will help surgeons make informed choices about whether potential benefits of these gloves are offset by sensorimotor impairment.

Subjects, materials and methods

Orthopaedic Registrars, Senior Registrars and Consultants (18 at the Royal Free Hospital and seven at the Royal National Orthopaedic Hospital) were used as subjects for this study to attempt to quantify the effect of wearing gloves intended to protect surgeons operating on 'high-risk' patients. Tests of sensory and motor function, normally used to measure progress after peripheral nerve damage, were used to assess performance parameters quantitatively. Surgeons performed eight tests under five conditions. These conditions were:

1 Wearing no gloves at all.
2 Wearing a single latex glove.
3 Wearing two pairs of latex gloves.
4 Wearing the latex–Repel-Lite®–latex combination as recommended by the manufacturers.
5 Wearing the latex–Lifeliner®–latex combination as recommended by the manufacturers.

Gloves were supplied by DePuy International and we used their Repel-Lite and Lifeliner gloves. The former is a woven glove liner containing a synthetic fibre called

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Kevlar® which renders the glove significantly more cut resistant than a cotton equivalent (manufacturer's data). The latter is similar, but augmented with Medak®—a processed natural hide which is puncture-resistant and covers the volar aspect of the fingers and distal palm. These gloves are intended for single-use and to be worn between two latex gloves. A sterile gel is also supplied to ease donning.

The order in which the surgeons wore the gloves was randomised to negate the effect of learning.

The tests are in common use in the Occupational Therapy Department at the Royal National Orthopaedic Hospital for assessment of the rehabilitative progress of patients with upper limb peripheral nerve injuries. They are

1 Texture matching

Three cubes on a single rotating axis with different texture materials on each of the four surfaces.

We recorded the time taken to align one set of three identically textured surfaces, eg corduroy, then proceeding immediately to match another set of three identically textured surfaces, eg sandpaper, while wearing a blindfold. The frequency with which errors were made were recorded.

2 Point discrimination

Three cubes on a single rotating axis with one, two or three metal studs on three of the surfaces and one surface with no studs. We recorded the time taken to align three identical surfaces (eg three studs on each) then proceeding immediately to match another three (eg unstudded) surfaces, while wearing a blindfold. The frequency with which errors were made was recorded.

3 Stereognosis with 2-D visual cue

We recorded the time taken to extract five wooden objects from a cotton bag to match five pictures displayed to the subject on a card. The bag contained ten objects: five identical to the pictures and five slightly different objects. The frequency with which errors were made was recorded.

4 Stereognosis without visual cue

We recorded the time taken to extract and identify five objects from a tin of lentils while not being able to see them. Each subject was foretold that the objects were: a screw, a pair of forceps, a piece of cotton wool, a button and a coin.

5 Motor function—pincer grip (thumb and index finger)

We recorded the time taken to transfer 20 marbles, one at a time, from one bowl to another using the pincer grip.

6 Motor function—tripod grip (thumb, index and middle finger)

We recorded the time taken to transfer 20 marbles, one at a time, from one bowl to another using the tripod grip.

7 Motor function—use of forceps—dominant hand

We recorded the time taken to transfer 20 wooden 1 cm cubes, one at a time, from one bowl to another using forceps in the dominant hand.

8 Motor function—use of forceps—non-dominant hand

We recorded the time taken to transfer 20 wooden 1 cm cubes, one at a time, from one bowl to another using forceps in the non-dominant hand.

Differences between the completion times for the thickest glove combination (Latex–Lifeliner–Latex) against double latex and no gloves at all were calculated using Student's paired t test (two-tailed).

Results

Sensory tests took approximately twice as long to perform in the thicker gloves compared with no gloves. However, the increased times for performing motor tests were modest in comparison. Figure 1 and Figure 2 show the magnitude of the differences for the individual tests with each of the glove tests.

Student's t test revealed significant differences in completion times for all motor tests and all sensory tests while wearing the thickest glove combination when compared with double latex ($P < 0.0001$ for motor tests and $P = 0.008$ for sensory tests) and also compared with no gloves ($P < 0.0001$). Error rates also increased very significantly with thicker gloves compared with double latex ($P < 0.0001$) and no gloves ($P < 0.0001$) (Fig. 3).

There was no significant effect of learning. Randomisation of the order of wearing different glove combinations led to an equal distribution for each run of tests. There was no significant reduction in completion times by the fifth run ($P > 0.075$, Student's t test, two-tailed for paired data).

Discussion

In vitro tests comparing the ability of gloves to clean a needle as it passes through (the 'wiping-effect') have demonstrated that a rate of HIV contamination of culture medium of 90% with only a single layer can be reduced to approximately half this rate with a double layer of latex. An extra layer of Kevlar in between reduces the rate to 6% and adding nonoxol-9 to the Kevlar layer prevents contamination completely *(3)*. Bennett and Howard *(4)* showed that the quantity of blood inoculated is dependent upon needle type, being greater for phlebotomy needles

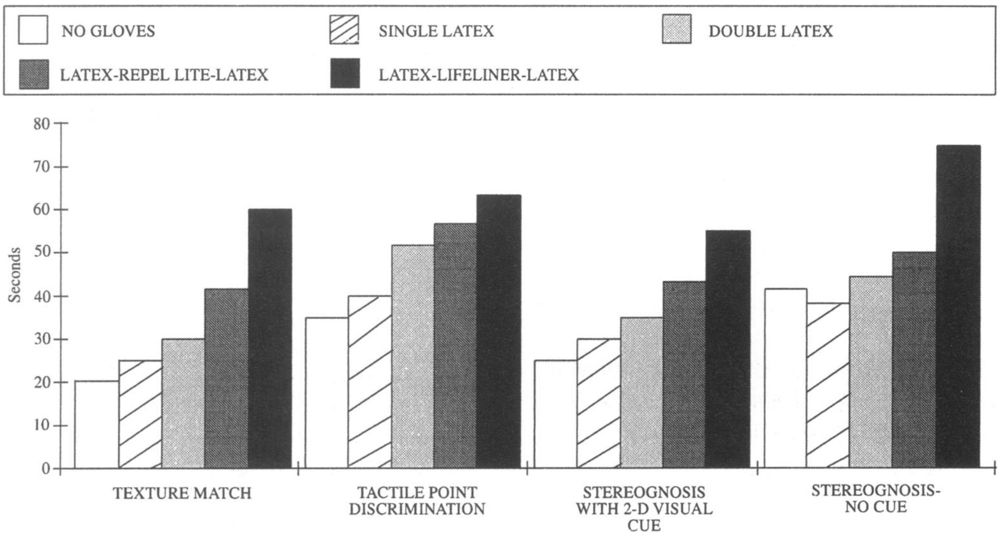

Figure 1. Mean completion times for the sensory tests.

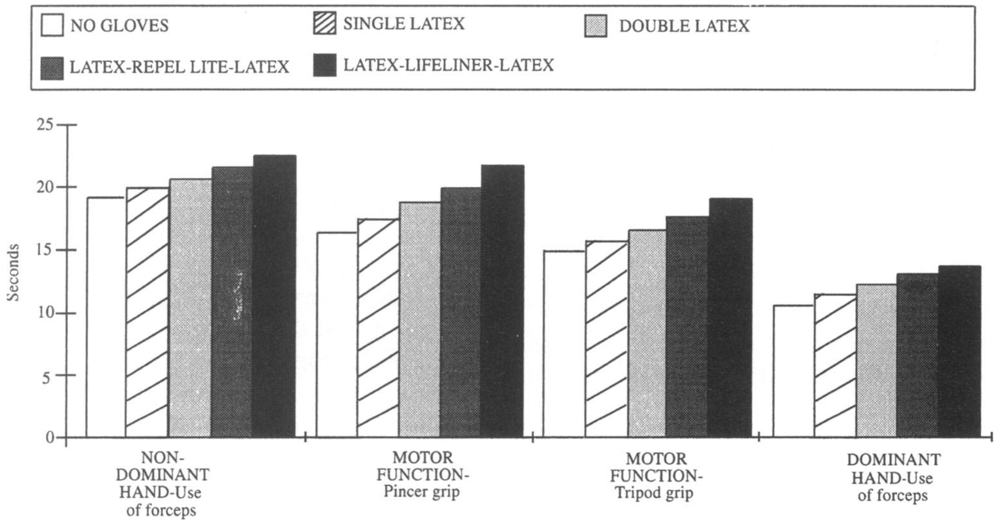

Figure 2. Mean completion times for the motor tests.

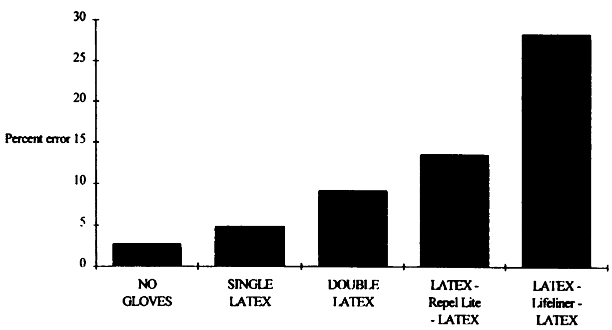

Figure 3. Mean error rates for each glove test.

than for suture needles. In their study, two layers of latex reduced the volume of the inoculum for suture needles (tapered and cutting) but not for phlebotomy needles. Inner glove perforation after an orthopaedic procedure is significantly less when a thicker 'orthopaedic' glove is used as the outer glove when compared with regular latex, and by introducing a Kevlar glove between two layers of latex the risk can be reduced further *(1)*. The non-dominant index finger and thumb are the most common sites for perforation to occur and reinforcement of these areas has been recommended *(2)*. The gloves we used in this study have been developed to address these problems, with Kevlar providing slash resistance and Medak providing needlestick puncture resistance. The increasing thickness of these gloves might be expected to impair dexterity and sensitivity. Dexterity tests using three different thicknesses of latex up to 0.83 mm have showed no significant effect on dexterity *(5)*.

We have used tests of dexterity to provide a standard task to measure the small differences in performance that we might expect from changing glove material/thickness. We were able to show that ability to perform sensory tests was significantly affected by the use of thicker gloves, and in general took about twice as long to perform and resulted in higher error rates. However, motor tests were not impaired as markedly but did take longer to perform with the thicker gloves.

The effect of learning during the tests was not as great as expected, there being no significant difference between the time taken to complete all the tests the first time compared with the fifth time. This was not due to there being a preponderance of subjects wearing the thicker gloves in their first run of the tests, thus having a neutralising effect.

Therefore we would suggest that where sensory discrimination is unlikely to be important to complete a procedure satisfactorily, eg knee or hip replacement, or when surgery is being performed under direct vision, ie most procedures, then these thicker gloves can be expected to produce less prolongation of the procedure than where sensory discrimination is likely to be of great importance during the procedure, eg excision of palpable soft-tissue lesions, hand surgery, metalwork removal or minifragment work or operations requiring accurate palpation of bony landmarks. We have quantified the magnitude of the effect of these different glove combinations on different sensory modalities and motor tasks to help surgeons to make an informed choice as to whether the impairment of performance is likely to be outweighed by limitations imposed on dexterity.

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