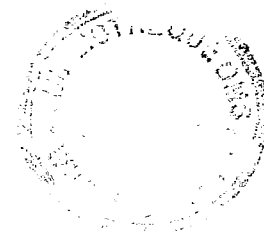




A COMPARISON OF MULTIPLE PRESSURE AND SCRATCH TECHNIQUES  
IN VACCINATION AGAINST SMALLPOX

by

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Since the pre-vaccinal inoculation days, it has been recognized that the deposition of pox virus between the skin layers is followed by infection. Over the years since Jenner introduced the use of vaccinia virus, a gamut of techniques has been used, from that of taking a stitch through the skin with a thread on which vaccine material had been dried, to a whole variety of intricate and ingenious devices capable of penetrating the skin to predetermined depths over precise areas - examples of the inventive ingenuity of man and the great practical importance of smallpox vaccination in the last century. With the advent of the period of antisepsis and asepsis, the trend moved again toward the simpler devices amenable to simple sterilizations, such as the lancet and the needle.

Data derived from the 1901-1904 smallpox epidemic in England indicated a lower mortality in those with multiple vaccination scars than those with only a single, and a lower mortality in those with a larger skin area involved in the scar tissue. However, studies on American college students, as judged by the response to revaccination, was not significantly related to the size of the scar among those with scarring. Mackenzie and Elkington, on British recruits, also found that immunity was not related to the number of the scars; there was a relation to the size of the scar area, but this did not seem of practical importance. Judging immunity by the average day of skin reaction after vaccination, the smallest scars gave an average of 6.8 days and the largest, 5.2 days, while the median days of maximum reaction of four groups, divided by the size of scar, were 7, 7, 7, and 6 (Leake, 1930). Based on this work the English Vaccination Committee concluded that "in place of the officially advocated four insertions, trial be made of vaccination and re-vaccination in one insertion, with a minimum of trauma" (quoted by Leake, 1930).

In the United States of America, vaccination practice was very strongly influenced by the work of Dr. J. P. Leake (1927, 1930). He was largely instrumental in introducing the multiple pressure technique of vaccination, an atraumatic technique effective in preventing smallpox. In addition, he felt that the smaller vaccination sites were effective prophylaxis against the not infrequent complication, in those days, of post-vaccinal tetanus. Further, it was his conviction (Leake, 1930) that in so far as the prevention of post-vaccinal encephomyelitis is concerned, "Reducing the size of the area vaccinated, and the dose of vaccine, seems to be important here". Accordingly, the multiple pressure technique using 30 pressures within five seconds for revaccination and "for primary vaccinations, where the slightest reaction compatible with successful vaccination is desired, and where other attempts with highly potent vaccine will be made promptly if the first is unsuccessful, the number of pressures may be reduced to 10, or even to a single pressure" (Leake, 1927). Excess vaccine is wiped off the arm, no dressing is applied.

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In the United Kingdom and in Europe, vaccination by the scratch method has been preferred, using a Hagedorn needle or a lancet. Multiple scratches with cross-hatching resulted in such severe scarring that it was forbidden by law in Germany. In general, the trend was toward a single scratch. However, when smallpox broke out in Glasgow in 1942, vaccine was applied through three incisions with a Hagedorn needle, each  $\frac{3}{8}$  inch long, with  $\frac{1}{8}$  inch between (Goodall, 1942).

Parish reported favourably on the multiple pressure method in 1944, and by 1956 he notes that:

"The multiple pressure method is now officially recommended both in this country and in the United States, because, in the experience of most experts, it gives a minimum of trauma and the smallest amount of secondary infection, without reducing the percentage of takes to any significant degree . . . Notwithstanding the increasing popularity and the undoubted success of the multiple pressure method, McClean (1955) has recently expressed the opinion that, especially in revaccinations, a single linear scratch not more than  $\frac{1}{4}$  inch (6.5 mm) long gives an even higher success rate. Using this method an attempt should be made not to draw blood. In the event of exposure to immediate risk of smallpox, he suggests two linear scratches not less than one inch (25 mm) apart. Personally, I prefer the multiple pressure method, which is easily learned but takes rather longer to perform than the single superficial linear scarification."

McClean (1955) states:

"The multiple pressure method of vaccination is now officially recommended in Great Britain in place of the single linear scarification. There is no doubt that, in the hands of those experienced with this method, a high success rate can be achieved with much less local trauma to the skin and consequently much less secondary infection. My own personal experience has led me to the slightly unorthodox conclusion that, especially in the revaccination of those already partly immune, a higher success rate can be obtained by the use of a single linear scratch not more than  $\frac{1}{4}$  inch (about 6.5 mm) long. In the face of an epidemic, when successful vaccination of contacts is vitally important, two linear scratches not less than one inch (25 mm) apart are advisable. There is now no point in the old method of multiple insertions by cross-scratching."

Despite these differences of opinion, relatively few comparative studies really have been carried out. In 1947, Mole reported results of a study on 122 airmen and 52 airwomen, all of whom had been vaccinated at least once and usually also in the preceding three months. One was vaccinated by the scratch method, using two parallel scratches  $\frac{3}{8}$  of an inch long through a drop of lymph placed on skin cleansed with soap and water (the epidermis was incised, but bleeding was avoided except by mistake), while the alternate individual was vaccinated with multiple pressure method, using 30 pressures of a Hagedorn needle through a drop of lymph. With both methods the vaccine was allowed to dry on the arm. Reactions were read on the second and fourth day, vesicular reactions were recorded as accelerated takes. There were more failures in both the men and the women (but more in men), more accelerated reactions in both groups with the multiple pressure method; the difference was statistically significant at the 5% level when the results were all considered together.

In 1958, Dr Espmark cited the work done by Sjöberg in 1954, who simultaneously vaccinated 230 persons by scarification and by the multiple pressure technique. 74.5% of insertions were "successful" after scarification in contrast with 97.1% after multiple pressure; these differences are very highly significant. Espmark also reported that in 1958 Lömberg vaccinated 185 recruits simultaneously by the two methods. 74% were successful after scarification in contrast with 83% after multiple pressure; these differences are significant at the 5% level.

Cross (1961) reported a series of studies which are highly pertinent to the question. He compared the results of two vaccinators using the scratch technique (a single 1/4 inch (6 mm) scratch). An experienced vaccinator (A) used the left arm and a vaccinator (B) who over the preceding two years had performed 5000 vaccinations used the right arm. The results read on the fourth and seventh days were:

<u>Type of response</u>	<u>Vaccinator</u>	
	<u>A</u>	<u>B</u>
Revaccination vaccinia	84	61
Accelerated reaction	90	57
Immediate reaction	13	10
Negative	3	62
Total	190	190

Thus, vaccinator B obtained major reactions in only 118 of the 174 individuals obviously non-immune according to the results of vaccinator A, i.e. vaccination had failed in 32% of the susceptible individuals.

In another study with vaccinator C, who had had experience of mass vaccinations for only six months but who understood that depth of insertion was an important factor, the following results were obtained:

<u>Type of response</u>	<u>Vaccinator</u>	
	<u>A</u>	<u>C</u>
Revaccination vaccinia	102	101
Accelerated reaction	81	65
Immediate reaction	3	6
Negative	0	14
Total	186	186

Despite the less experience, only 9.3% failed when attention was paid to depth of scratch.

In the next study, vaccinator A alternately performed 100 primary vaccinations with a deep scratch and 100 with a superficial scratch; all with a deep scratch had "takes" as did 97% with a superficial scratch. 144 revaccinations were performed by the same individual, using a deep scratch on one arm and a superficial scratch on the other arm. With a deep scratch, 133 developed major reactions but only 91 did so with the superficial scratch; i.e. 31% failed!

These results are compatible with those reported by Goodall (1942), when, in the face of the Glasgow outbreak, three scratches were performed because of the poor take rate experienced with a single. In an analysis of 618 vaccinations, blood had been drawn in 185 and no blood in 333; 104 (56%) of those on whom blood was drawn were successful in contrast with 140 (42%) of those on whom no blood was drawn. The differences are significant ( $\chi^2 = 9.6$ ).

Finally, Cross performed 25 primary vaccinations with the multiple pressure technique, using deep pressures alternately with 25 using "superficial pressures". All with the deep pressure had takes, compared to only 80% of those with superficial pressures. It is to be noted that Leake (1927) felt that the rapidity of the pressures, six per second, effectively controlled the amount of pressure. His concern was excessive pressure, and he states "provided the needle is held quite tangential to the curve of the arm, and the direction of motion is quite perpendicular to the needle, it is difficult to make the rapid pressures too firmly. Experience is necessary, however, in judging the penetrability of the epidermis in different arms; reaching the papillae of the corium is unavoidable in some cases". Bourke &

Clarke (1963) studied the results of three vaccinators on alternate subjects, vaccinated either by linear scratch or the multiple pressure technique, using a separate capillary tube of lymph for each individual. Scratches were made deep enough "to draw the smallest visible punctum of blood at some point along the length of the scratch". All three vaccinators used a vertical skin break, two less than 1/4 inch scratch and one used a scratch 1/4 to 1/2 inch long. The standard multiple pressure technique according to Leake (1927) was used; two vaccinators used 10 pressures for the primary and the third, 24; for revaccinations, one used 10 pressures, another 24, and the third 30. Vaccinations were inspected on the eighth day, and those without a palpable indurated papule (major reaction) were revaccinated. The results indicated that "there is a significant difference between the success rates of the two methods of vaccination, and separate analysis showed that varying the number of pressures in the multiple pressure technique or varying the length of the scratch, at least within the limits outlined, is not of importance in obtaining successful vaccination". Thus, of 994 vaccinations, 76.7% were "successful" by the scratch method in comparison with 85.7% by the multiple pressure ( $P < 0.001$ ). This difference applies only to revaccination; on primary vaccination  $P = 0.72$ . With the scratch method, 81.7% of 186 women and 73.6% of 299 men developed takes; this difference is significant:  $P = 0.04$ . However, analysis of the period since last vaccination showed that men had been more recently vaccinated. When this variable is corrected,  $P = 0.10$ . With the multiple pressure method, on the other hand, there is no difference in response by sex (86.6% vs. 83.7% takes). Interestingly, the multiple pressure technique does give a significantly higher percentage of takes among the females ( $P = 0.63$ ), but there is a significant difference between the two techniques in males ( $P < 0.001$ ). This difference applies to revaccination and not to primary vaccination. In analysis of the interval since last vaccination and of the number of previous vaccinations, multiple pressure consistently elicits a higher percentage of takes.

Finally, Petersen & Nørby (1966) compared the results of revaccinations with multiple pressure technique with those of the lancet technique normally used in Denmark. In this technique, the point of a lancet is introduced into the upper layers of the epidermis through a droplet of lymph, and then drawn outward. A total of 380 individuals were vaccinated at two sites 2 cm apart by the lancet in comparison with 383 on two sites by multiple pressure. Takes were obtained in 41.8% of the group with the lancet, in contrast with 73.1% with multiple pressure. The difference is highly significant.

Thus in all comparative studies where a common lot of vaccine was used, the multiple pressure technique was more effective in infecting the individual with waning immunity. In primary vaccinations, either technique was effective; however, the multiple pressure technique with six or fewer pressures permits a minimal lesion with decreased likelihood of complications. On revaccinations, multiple pressures with 30 insertions presumably provide more possibilities for a virus particle to be brought into contact with a susceptible cell. The only negative study is that of Cross, in which deliberately using light pressures, there were 20% failures on primary vaccinations. However, the technique as described by Leake is one in which relatively heavy pressures are required to effect the six up-and-down movements per second.

No evidence has been presented to correlate bleeding with success in the multiple pressure method. However, Cross's work indicates that it is necessary for a scratch to be relatively deep, confirming the analysis by Goodall. The opinion of Wolpe that "very light scarification, producing only very tiny points of bleeding, even after a minute, gives best results" may be confirmatory. However, he states that "this is only an impression; but it is perhaps supported by the fact that the first vaccination, at Holfontein, where all vaccinations were light, gave somewhat better results than the first vaccination at Welgedacht, where a large number of scarifications were deep". In this study, obviously, the potency of the vaccine may have been considerably different.

Other methods of applying the vaccine virus are not pertinent to the individual vaccinator in his routine work. The use of rotary drills, such as used in India and Pakistan, can be rationalized only when ineffective vaccine was the best available; with freeze-dried vaccines of the present day, they are mentioned only to be condemned as excessively traumatic.

and as a deterrent to smallpox eradication by causing the meek to flee the vaccinator, rather than seek him out. Jet injection is designed as a device for mass immunization campaigns, and not for the individual vaccination.

The final selection of the method for the individual vaccinator is influenced by the acceptability by the vaccinee, effectiveness in producing immunity, the speed and facility of performance, and the relative difficulties in teaching the technique to uneducated and unskilled vaccinators. The multiple pressure method is less traumatic and therefore better accepted and in all comparative studies has been more effective than the other methods in establishing a vaccinal infection. The speed and facility of performance is comparable in the two methods - the proponents of each claim that their method is faster and easier! The argument most frequently raised for the scratch over the multiple pressure method has been that the multiple pressure method requires more instruction before it is properly performed, and, by implication, the scratch method does not require such technical competence. While technique is important in the multiple pressure method, it is not difficult to teach. 118 revaccinations were performed at the same time by two vaccinators using the same potent lymph; only 46% of the 66 non-immune developed a major reaction at both sites (Benenson, 1962). However, this difference was established in the first 84 vaccinations; in the last 34 performed, the "take" rate of the two vaccinators was comparable. When performed properly, the concern with the multiple pressure is that of excessive pressures, rather than too superficial insertions. On the other hand, the failure of vaccinator B in Cross's study to elicit major reactions from 31.2% of the 174 non-immunes uncovered by vaccinator A, after two years' experience and 5000 vaccinations, indicates the great importance of the depth of the scratch; i.e. the need for training. It is to be noted that only non-American comparative studies have been cited, so that the multiple pressure technique was being applied by those new to its use.

While it must be admitted that those expert in a technique will obtain best results with it, the weight of evidence argues for the choice of the multiple pressure technique for the training of all new vaccinators, to the exclusion of the scratch, lancet, or rotary drill, until newer methods might be shown to be better.

REFERENCES

- Benenson, A. S. (1962) Revaccination against smallpox, Symposium International sur la Vaccination Antivariolique, pp. 128-132
- Bourke, G. J. & Clarke, N. (1963) Smallpox vaccination - success rates of scratch and multiple pressure techniques, Brit. med. J., ii, 281-285
- Cross, R. M. (1961) Observations on the classification and interpretation of reactions to smallpox vaccination, Bull. Wld Hlth Org., 25, 7-17
- Espmark, A. (1958) Vaccination against smallpox, Svenska Läk.-Tidn., 34, 17
- Goodall, A. L. (1942) Some statistical notes on vaccination, Glasg. med. J., 138, 143-145
- Leake, J. P. (1927) Questions and answers on smallpox and vaccination, Publ. Hlth Rep., 60, 221-235
- Leake, J. P. (1930) Vaccination, New Engl. J. Med., 202, 937-941
- McClellan, D. (1955) The use of smallpox vaccine, Bull. Wld Hlth Org., 13, 437-445
- Mole, R. H. (1947) Multiple pressure vaccination, Lancet, i, 597
- Parish, H. J. (1944) Smallpox vaccinations by the multiple pressure method, Brit. med. J., ii, 781-784
- Parish, H. J. (1956) The reasons for urging smallpox vaccination in Great Britain, Practitioner, 176, 532-536
- Petersen, E. S. & Nørby, G. (1966) A comparison between two techniques of smallpox vaccination, Dan. med. Bull., 13, 168, 169
- Wolpe, J. (1945) Report on 3052 vaccinations with special reference to the value of repeated attempts, S. Afr. med. J., 19, 339-340