

## A STUDY OF HYPODERMIC NEEDLE POINTS

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BECAUSE of the introduction of new therapeutic agents requiring subcutaneous, intramuscular, or intravenous injection, the procurement of needles and syringes has become a source of increasing expense to hospitals and to physicians. At Hartford Hospital, over 60,000 needles have been procured in the last three years. During that period, demands placed upon the purchasing agent have increased by 50 per cent to the point where one needle is required per bed approximately every ten days. The cleaning, packaging, sterilization, and issuing of needles to wards from central supply constitute a major effort that is complicated by problems of collection and resharpening prior to processing for reissue. It is with the problem of resharpening that we are concerned in this communication.

Sharpening of needles of a caliber larger than 22 gauge can be accomplished relatively easily by skilled personnel using a fine emory stone or an electrically driven grinding wheel obtainable on the open market. In the past, it has been the traditional procedure for a nurse to use a hypodermic needle, gauge 24 or 26, repeatedly, until the point was obviously dull and then to discard it, knowing that to sharpen such a fine needle was an impractical procedure. Nurses, with an acute sense of economy, were faced with the problem of deciding when a needle should be considered dull and therefore discarded. Patients were known to complain of pain when a needle they considered dull was still retained in use. Since one-third of the needles procured are in the "hypo" class, 25 gauge, the problem of sharpening these small needles seemed worthy of investigation. Because it was known to be impractical to sharpen them by hand it was resolved to design an apparatus for the purpose. The immediate problem was to decide upon the characteristic of the point and bevel that would be satisfactory to both therapists and recipients. A study therefore was undertaken to establish specifications for points and bevels in order that one of us (F. F.) might design a mechanical sharpener for the purpose.

The efficient hypodermic needle must be designed and maintained to provide an entrance through skin and into tissue with the concomitant production of a minimal amount of pain and minimal damage to structures traversed. The proper shape of the point and bevel necessary to fulfill these criteria has long been a controversial subject. The correct shape, specified in terms of results desired, is one which will slice the smallest area of tissue necessary to admit the cannula, produce the least pain, and cause the least seepage of lymph, serum,

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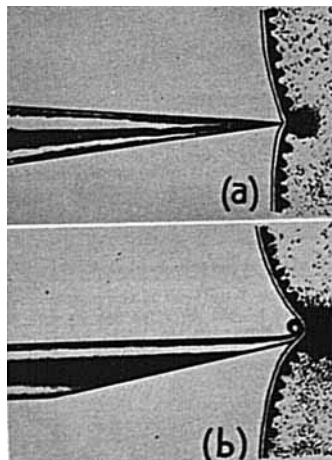


FIG. 1 (a). The point of a conically shaped sewing needle enters the skin easily but as the full diameter of the shaft expands the tissue stretching occurs and the hole remains open after the needle is withdrawn. (b) With a hooked needle, greater force must be exerted to effect entry through the skin and trauma to tissue results.

or blood. The first requirement is that the slit produced be less than the full diameter of the needle. Advantage thus may be gained of the inherent elasticity of tissue which permits expansion to the extent of the full circumference of the needle as it enters and contraction to close the opening when it is withdrawn. A second requirement is that the slit surface be flat, since any deviation from a plane slit will increase the area traumatized. Increased seepage can result when tissue is pierced with an ordinary, conically-pointed sewing needle since the point enters in a very small area, but the shaft expands the tissue and

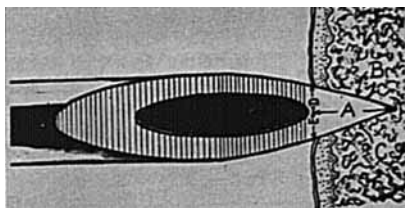


FIG. 2. As the point is introduced distance A, cutting edges B and C are "drawn" through the skin to create an incision of lesser length, D and E.

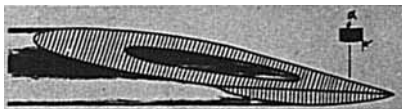


FIG. 3. The bevel is narrowed by honing the sides until they meet at the point. The edges are honed square with the bevel face producing a blunt (90 degree) "cutting" surface.

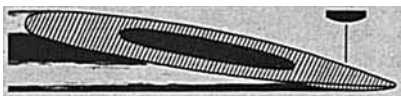


FIG. 4. As in figure 3 the bevel is narrowed by honing at a right angle to the bevel face but the narrowing has not been extended to the point. Both point and bevel edges are "dull."

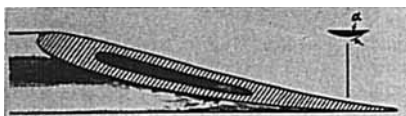


FIG. 5. The bevel is hollow ground, the radius of which is 18 times the needle's diameter. A sharp point and keen cutting edges are present but hooking occurs easily.

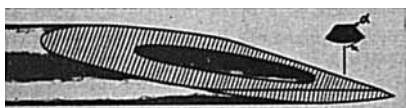


FIG. 6. The bevel is narrowed by honing at 45 degrees to the bevel face. The point is sharp, the cutting edges are keen but this shape is difficult to maintain in sharpening needles finer than 22 gauge.



FIG. 7. The bevel is narrowed by honing at an angle of 45 degrees on the reverse side. Note the cross section.

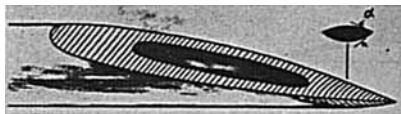


FIG. 8. This needle has been honed on both the bevel face and the reverse side to produce a cross sectional area in the form of an ellipse. The point is sharp, the cutting edges keen and the bevel is resistant to hooking.

eventually tears it along its lines of least resistance (fig. 1a). The situation is similar, although even more undesirable, when a hooked hypodermic needle is inserted into tissue (fig. 1b). The hooked hypodermic needle does not enter in an infinitely small area but in an area of definite magnitude. Thus, considerable force is required to start the needle through the epidermis and succeeding layers of tissue, and tearing the tissues causes the patients considerable and inexcusable pain. The operator loses his sense of feel, and precise placement of a dull needle is rendered difficult.

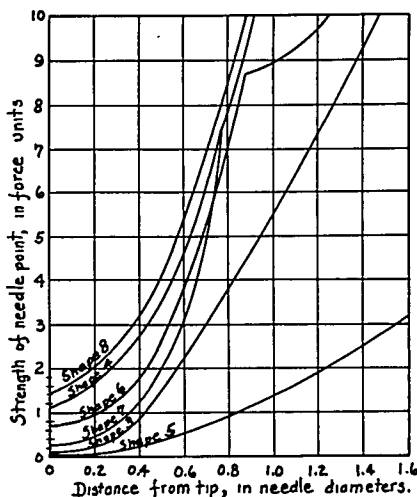


FIG. 9. The strength of cross sectional shapes have been plotted at indicated distances from their points. Shape numbers 3 to 8 correspond to figures 3 to 8.

The problem, therefore, resolves itself into the production of a keen cutting edge at the entering point of the needle. From an engineering point of view, as the cutting edge is made more keen, it is also made weaker simply because it must be made thinner. A practical compromise must be effected between the strength of the metals that are available and the desirable degree of keenness of the edge at the point. It is particularly unfortunate that thin cutting edges reduce the strength of hypodermic needles, since it is not feasible to manufacture these needles of strong, hard material. There are two cogent reasons for this latter statement: first, in order that the needle be highly resistant to corrosion, "austenitic" stainless steel must be employed and such steel cannot be hardened by heat treatment; and second, hypodermic

needles must be made of ductile, and consequently weak, material. Such needles will bend rather than break when subjected to stresses during insertion.

The effectiveness of a keen cutting edge can be increased by drawing the edge during cutting, as in slicing bread. The cut will progress with a lighter force than that required to press the cutter squarely through the medium. The lighter force required will result in less distortion of the material. This phenomenon occurs when hypodermic needles are inserted. It permits the employment of a blunter but stronger, cutting edge. Figure 2 is illustrative. The needle has been

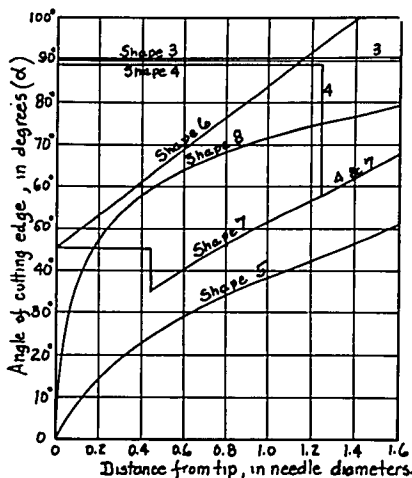


FIG. 10. Keeness of cutting edges is indicated by plotting the angle of cutting edges as indicated distances from the points of needles, shape 3 to 8 as shown in figures 3 to 8.

inserted a distance A, but each cutting edge B and C, has slit the tissue only the fractional distances, D and E respectively.

In the present study the usual varieties of needle points (figs. 3 to 8) encountered in clinical practice were examined and evaluated. The strength and edge-keenness were computed, and the curves of strength (fig. 9) and the curves of keenness (fig. 10) were plotted. All needles were taken as having a diameter of one unit (hereafter referred to as  $d$ ) and a bevel length of 4.2 units (so-called "long bevel" needles). The column strength, an engineering term indicating resistance to buckling in the weakest planes of a specimen, was taken as the measures of the resistance to "fish-hooking." The angle  $\alpha$  (Figs. 3, 5, 6, and 8) along the leading edges was taken as the measure of keenness.

As expected, from the curves of strength (fig. 9) all shapes of needle points are weakest at the extreme tip, and are stronger more distal to the point. In all instances the weakest section is within  $0.2 d$  from the tip. This explains why needles "fish-hook"; the extreme tip yielding first and subsequent sections progressively curling as the destructive load increases. Some needles (figs. 3 and 5) are weak not only at the extreme tip, but are weak up to  $0.2 d$  and even  $0.4 d$  from the tip. Others (figs. 4 and 8) are not only stronger at the tip but their strength increases more rapidly at more distal sections. On the basis of strength alone the choice of shapes would be as in figures 8, 4 and 6, in that order, the others being relatively too weak to warrant consideration. On the basis of curves of keenness (fig. 10) the sharpest shapes, figures 5 and 7, must be rejected because they are the weakest. We rejected the shape shown in figure 4 because the angle of the cutting edge is 90 degrees at the entering tip, whereas the shapes in figures 6 and 8 are much keener. The cutting edge angle of the shape in figure

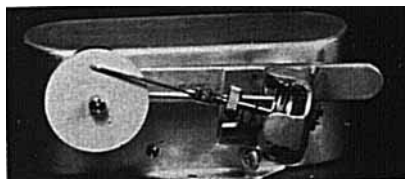


FIG. 11. The sharpener designed to produce points and bevels as indicated in figure 8.

6 begins at 45 degrees and that in figure 8 begins theoretically at 0 degrees (infinite sharpness).

The needle shapes which are satisfactory are those combining both strength and sharpness of cutting edge. Only 2 of the samples examined satisfy both these criteria (figs. 6 and 8). One of these is a hypodermic needle point in its original form as received from a manufacturer (fig. 6). The other, figure 8, is the point selected for development of a mechanical needle sharpener (fig. 11). Both the needle and the grinding wheel rotate. It is so designed that as the needle rotates it lifts away from the wheel in order to preserve the cutting edges of the bevel. A convex bevel is produced and hooks curled backwards from the beveled surface are ground away.

#### SUMMARY

The maintenance of needles in a condition satisfactory to patients is a real problem. In order to provide specifications for development of a sharpener suitable for reconditioning fine hypodermic needles, a study of desirable points and bevels was undertaken. Having established satisfactory criteria, design and construction of an apparatus that has been proven useful was accomplished.