A study relating wound tension to scar morphology in the pre-sternal scar using Langers technique

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SUMMARY. Using the techniques of Karl Langer (1861) a cadaver study has been performed to relate the pattern of skin tension to scar morphology found in the pre-sternal scar. It is demonstrated that hypertrophic scarring occurs in areas of high tension with "pull" in many directions, but that a stretched scar results from increased tension in one axis only.

In 1861 Karl Langer, Professor of Anatomy at Josephs Academy in Vienna presented four papers "On the Anatomy and Physiology of the Skin". An excellent translation of these papers by Professor T. Gibson was published in this journal in 1978. In the second of these papers, "Skin Tension", Langer performed a detailed and extensive study in patients and cadavers in which he examined the degree and direction of tension in various parts of the body. The bulk of the work was performed on cadavers on whom Langer used a wooden circular template with a painted free edge to mark the skin. He then cut along this circular outline to produce a central disc of skin which he called the "Kernel", and an outer retracted skin margin (Fig. 1) which he called the "Opening". Langer measured the distance between these two, and used it as his indicator of the degree and direction of tension for any particular part of the body. We have used a similar technique to examine the relationship between skin tension and scar morphology. We used the pre-sternal scar as our model. This common scar is known (Elliot et al., 1985) for its tendency to hypertrophy over the body of the sternum, especially in females, and stretch over the upper abdomen. Correlations between this tendency and the pattern of skin tension found are discussed. Although Langer did study the skin tension in this part of the body using the technique already described, he touches on it only lightly and gives measurements for only one cadaver. It does appear that our findings in the thoracic area match with those he reported. However our observations for the upper abdominal area would seem to differ from those of Langer.

Method

Ten cadavers were examined in the study. Using a skin biopsy "punch" (Fig. 2) with an internal cutting diameter of 5.5 mm, circular incisions were made at certain pre-determined and measured points (Fig. 5) along the midline from the jugular notch (Point A) down to just above the umbilicus (Point H). From the "Angle of Louis" to the xiphistemum and from thence to the umbilicus these points were equidistant. The transverse and vertical diameters for each "kernel" and "opening" were then measured using a pair of dividers. All cadavers were examined within 4 days of death (usually within 2 days) in the hospital mortuary. An added advantage in choosing the midline for the measurement of skin tension and scar morphology was that this simulates...
Results

It can be seen (Figs 3 and 4) that for the kernels there are no sudden alterations in the extent of contractions in both axes as one progresses downwards, with the possible exception of point "A" (jugular notch) which tended to contract rather more. If the degree of tension is reflected by the amount of contraction, as Langer believed, then for the kernels it must be approximately equal throughout. Whereas the extent of contraction is an indication of the amount of tension, the change in shape is an indication of the direction in which the tension is acting. This is best demonstrated by examining the ratio of the horizontal to the vertical diameters. When the ratio is less than one the shape is tending toward a vertical ellipse. When the ratio is one it suggests that the shape is circular. Greater than one is an expression of a horizontal ellipse. The ratios for the kernels (Fig. 5) all approximate very closely to one, i.e., they are all circular and therefore the tension within each must be evenly distributed. If the measurements for the outer openings are examined, it can be seen that as we proceed down the midline the extent of retraction (Figs 6 and 7) varies quite considerably for both axes, i.e., the amount of tension varies considerably. If the ratio of the vertical to horizontal diameters (Fig. 8) is examined, as was done for the kernels, it can be seen that it changes markedly, i.e., the shape and therefore the direction of the predominant tension is very different in different parts of the line representing the pre-sternal scar. At point "A" the ratio is 0.95 i.e., almost circular with the horizontal diameter slightly greater than the vertical, probably explained by the very extended position of the head on the mortuary table pulling on the skin overlying the manubrium. It remains close to one over the sternum, but as we proceed down to the umbilicus the ratio continues to increase until at point "H" it is 1.38, in other words a manifestly horizontal ellipse. Therefore it seems that over the sternum the tension is acting in all directions as indicated by the almost circular shape of the outer openings, but in the upper abdomen the tension is predominant acting in a horizontal axis as indicated by the outer openings becoming horizontally elliptical. To determine whether or not the difference found in ratios for the outer openings of the chest and abdomen was statistically significant, the mean ratio for holes B, C and D was subtracted from the mean ratio for holes F, G and H for each cadaver. The mean and standard error of this difference for all ten cadavers was then compared. The mean difference between the average ratio in the chest and abdomen was 0.172 (standard error 0.008). This is clearly unlikely to have arisen by chance from a situation in which chest and abdomen ratios are the same.

Discussion

The uniform behaviour of the kernels would seem to suggest that their retraction is a manifestation of the intrinsic skin tension at any particular point, since the isolated disc of skin is free from the influence of any external forces. However, the change in shape of the outer openings seems to represent the sum of all the forces acting on that piece of skin.

The change in shape of the outer openings shows a trend which allows them to be divided into two groups (shown to be statistically different), the openings over sternum being roughly circular and those over the upper abdomen being horizontally elliptical. According to our interpretation of the distortion of the outer openings this means that over the sternum the lines of tension act in all directions, whereas over the upper abdomen the overwhelming tension is acting predominantly in the horizontal plane. In a paper by Elliot et al. (1985) 73 fair skinned patients were examined after cardio-thoracic surgery to examine the nature of their pre-sternal scars in a study comparing the relative merits of suture materials. No keloid scars were found but there did emerge a detectable pattern with respect to the formation of stretched or hypertrophic scars, although there were many variations within individuals. Essentially they found that over the body of the sternum the scar tended to hypertrophy especially in women and that over the upper abdomen the scar tended to stretch especially in men. Over the manubrium the scars were generally good with only a small percentage either stretching or becoming hypertrophied.

If the deductions made about tension throughout the scar are matched with the pattern of scar formation as found by Elliot et al. it can be seen that where the tension is acting more or less equally in all directions, as it is over the body of the sternum, then the result is likely to be hypertrophic scarring but where tension is strong and acting predominantly in one direction as in the upper abdomen then the result is likely to be a stretched scar. This external tension in the living patient is probably exerted by the surrounding skin, the movement of local joints, pressure from within (e.g. in the pregnant abdomen) and gravity. In the case of the pre-sternal scar it is probably the movement of the nearby neck and shoulder joints that particularly contributes to this external tension.

A simplistic explanation might be that the wound fibroblast, the key cellular component of wound healing, is in some way stimulated by the tension acting across the wound (Sommerlad and Creasey, 1978; McGraw, 1986) to lay down what it deems to be an appropriate amount of collagen in an attempt to resist this tension and repair the defect. In the case of hypertrophic scarring it may be that significant tension acting in many directions serves only to overstimulate the fibroblast causing it to produce an excess of collagen which is the main constituent of the scar.
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Figure 3—Vertical contraction of the kernels. Mean value (± 1 Std Error). Figure 4—Horizontal contraction of the kernels. Mean value (± 1 Std Error). Figure 5—The ratios of the vertical to horizontal diameters for the kernels. Figure 6—Vertical expansion of the outer circles. Mean value (± 1 Std Error). Figure 7—Horizontal expansion of the circles. Mean value (± 1 Std Error). Figure 8—The ratios of the vertical to horizontal diameters for the outer circles.
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References


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