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SHORT NOTE

AN IMAGE ANALYZING PROCEDURE FOR THE DETERMINATION OF MEAN MUSCLE ORIGINS - MUSCLES OF THE INTEROSSEOUS MEMBRANE OF THE FOREARM

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The delineation of the area of muscle origin and insertion varies substantially from one author to the other. This uncertainty has, at least in part, resulted from the lack of an objective method for the determination of a mean representative area of muscle origin on the basis of a large sampling. This paper is intended to present such a method.
The example (fig.2A) demonstrates the area of origin of the Flexor digitorum profundus on the interosseous membrane. This area was determined from a sample of 25 adult individuals of both sexes.
The deep flexors and extensors were removed except for the last 10mm at their attachment. They were subsequently encircled with lead wire and X rayed. By this procedure, the contour of each individual muscle origin was recorded and could be transferred to a uniform prepared sketch of the radius and ulna (fig.1). These schematic drawings were analyzed with an IBAS II image analyzing system (Kontron, Eching, FRG). Each drawing was imaged by transmission illumination, which was received by a K30 videocamera (Siemens, Berlin, FRG) through a S-Orthoplanar macro lens, (Zeiss, Oberkochen, FRG) and digitized on a matrix of 512x512 image points (=pixels).

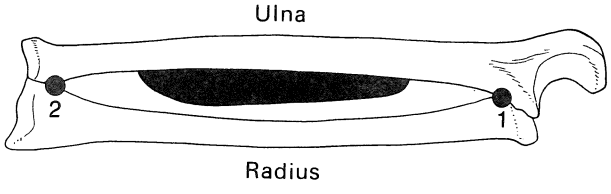

Fig.1. Drawing of the interosseous membrane with radius and ulna. The reference points for the alignement of the drawings (points 1 and 2) and the area of origin of one individual are shown.

The drawings were aligned for image input in the following manner: The proximal and distal intersections of radius and ulna (points 1 and 2 in fig.1) were superimposed upon two fixed marking points on the glass plate of the illumination system. This was done, so that pixels with the same coordinates (i,j) from different drawings represent an analogous location on the interosseous membrane.
The segmentation of the images into pixels in the area of muscle origin and in the surrounding "background" area was performed using a global thresholding procedure. A value of 1 was assigned to the pixels at the muscle origin, a value of 0 was assigned to the others.
This set of images was added up point by point on the IBAS II according to the following rule:

$$s(i,j) = \sum_{k=1}^{n} p_k(i,j) \qquad (1 \leq i,j \leq 512).$$

"n" is the number of images, i.e. the number of individuals tested, k (1<=k<=n) is the running number of an image and pk(i,j) is the value (1 or 0) of an image point in the image k at the location (i,j).
To get a better idea of this process, one might visualize the image s(i,j), as a mountain on the interosseous membrane. The elevation of the mountain at any given point (i,j) is proportional to the absolute frequency with which this point is covered by areas of muscle origin.
Different frequency levels, which are given by the s(i,j) values, can be defined and presented as areas by the image analyzer:

1. s(i,j)=0 These image points are not covered by any area of origin and therefore constitute the image background.
2. s(i,j))0 Image points meeting this condition constitute an area that describes the total range of variation of a given area of origin (white inner contour in the membrane in fig.2A). All points of this area are at least covered by a muscle origin in at least one specimen. The area can only become larger if a larger sample is taken.
3. s(i,j)=n The points of this area are covered by all areas of origin (white area inside the black contour in fig.2A). If the location of muscle origin varies considerably, this level may be very small, or even missing. The area can only become smaller with increasing sample size.
4. s(i,j))=c, c=(n+1)/2 for odd n, c=n/2 for even n.
This area (white area of fig.2A including the area described in 3.) shows the points covered by at least 50% of the areas of origin. The size of this area does not vary systematically with increasing sample size and is defined as the mean representative area of muscle origin.

Due to the image analyzer hardware, (8 bit word), the value of one image point is limited to the range 0-255. This means, that a maximum of 255 images may be added up. For a larger sample, the range 0-n has to be rescaled linearly to the range 0-255, thus allowing an unlimited sample size. In the definitions given in 3. and 4., n must be replaced by 255 if a sample larger than 255 is taken.

The choice of an area defined in this way as the mean representative area of muscle origin may be explained by an other way of constructing this area. Consider the set of the superimposed contours of the individual areas of muscle origin, and a point P which is surrounded by all the contours. If the set of points for each area of origin is convex, a radius from P with arbitrary orientation will intersect each contour once. The distances of the points of intersection from P have a median value X. The contour of the mean area can be defined by the set of median values X calculated for a sufficient number of orientations.

The suitability of this definition of a mean area of muscle origin is shown in fig.2B in the example of the deep extensors at the interosseous membrane (30 individuals). This method is applicable to other groups of muscles and skeletal elements. The results gained by using this method will be reported in future papers. (Moellers et al., in press).

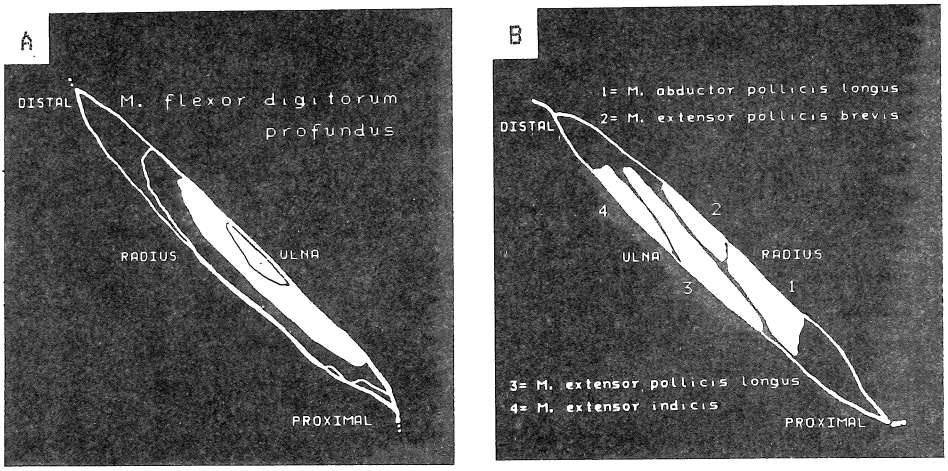

Fig 2AB. A: Computergraph of the muscle origin area, with frequency levels (s(i,j)))=1,)=13 and =25 taken from a sample of 25 individuals.
B: Areas of origin of the deep extensors at the interosseous membrane shown as means from a sample of 30 individuals (s(i,j))=15).

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REFERENCE

Moellers N, Koebke J, Schleicher A. Quantification of muscle origin at the interosseous membrane of the forearm. Anat Anz 1985, in press

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