TREFOIL CONFIGURATION AND DEVELOPMENTAL STENOSIS OF THE LUMBAR VERTEBRAL CANAL

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The midsagittal and interpedicentral diameters and the trefoil shape of lumbar vertebrae of known age at death were measured in skeletons from a population aged between 1 and 70 years.

All the trefoil configurations were at L5 with the exception of one at L4. The overall prevalence was 25%, but this shape was not generally apparent until adulthood.

The midsagittal diameter in the trefoil canals was found to be significantly smaller than that in the unaffected canals. This did not change significantly after six years of age indicating that the cause of the trefoil configuration is probably present early in life. The trefoil shape was no more common in the spines of the elderly subjects.

Our findings indicate that the trefoil configuration of the lumbar vertebral canal has a developmental origin and is not a consequence of degenerative processes.

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Verbiest (1954, 1955, 1975) first reported cases of central narrowing of the lumbar vertebral canal in adults in whom he drew attention to the hypertrophy of the laminae. He suggested that abnormalities in the diameters of the canal may be present at birth, but that progressive thickening of the laminae and articular processes in adulthood is the cause of compression of the neural elements. The trefoil shape of the vertebral canal occurs when the posterolateral sides are concave and protrude into the canal. This indentation is symmetrical hence the trefoil or maple-leaf appearance (Armstrong 1952).

Some clinicians consider that facet osteophytes are chiefly responsible for the appearance of the troublesome trefoil shape of the lumbar canal (Verbiest 1954; Kirkaldy Willis et al 1974). Eisenstein (1977, 1980) suggested that developmental stenosis was associated with this configuration but he did not find any correlation with sagittal narrowness. Porter (1980) also supported the developmental hypothesis in finding no correlation between degenerative changes and the trefoil configuration. Epstein, Epstein and Lavine (1962, 1964) identified a relationship between small sagittal diameter and a narrow lateral recess.

The trefoil shape of the lumbar canal is commonly seen on CT or MRI in patients with low back pain and with radicular symptoms. Hence an understanding of its origin is important.

MATERIALS AND METHODS

We examined the lumbar spines of 185 skeletons from the Spitalfield Collection at the Natural History Museum, London. This collection originates from immigrant French Huguenots between the 17th and 19th centuries. Exact records of their births and deaths have been preserved. Their ages were between 1 and 70 years: 41 were infants (16 months to 5 years), 43 were juveniles (5 to 16 years) and 101 were adults (16 to 70 years). There were 210 lumbar vertebrae missing or damaged, leaving 715 available for investigation.

Silhouettes, unmagnified photographs of the lumbar vertebral canals were taken using a specially designed photographic box as described by Porter and Pavitt (1987). The images obtained were of the most proximal aspects of the canals, since it is at this level that the central canal is physiologically narrowest and therefore most important clinically in regard to space-reducing lesions (Fig. 1).

The midsagittal diameter, interpedicentral diameter and the shape were measured by computerised image analysis which gives an accuracy to the nearest 0.01 mm. The trefoil shape was expressed as a ratio of a transverse measurement taken at one-third of the distance from the midpoint of the interpedicentral diameter to the apex of the neural arch, and the full interpedicentral diameter. A vertebral canal is trefoil in shape if the ratio is less than 0.6667. The values through childhood and adult life were compared with the midsagittal and interpedicentral diameters. The components of this ratio alter, however, as the length of the sagittal diameter changes. We therefore used another method to investigate a possible correlation between the midsagittal diameter and trefoil shape. One of the most relevant ele-
magnified silhouette images of the canal.

The increase in trefoil shape was significant only until adulthood. Canals in which the ratio was less than 0.667 were regarded as trefoil-shaped.

The ratio tended to decrease in the first two decades of life (p < 0.001) as the shape of the canal approached that of a trefoil. Over 16 years of age no significant change was found in the measurements between the separate age groups (Fig. 3). In infancy an almost circular dome-shaped lumbar canal is usually seen. By adulthood it becomes triangular and in some of the vertebrae the sides become concave producing the trefoil shape. Table I shows the measured dimensions of trefoil and non-trefoil canals in different age groups.

In the adult spines the midsagittal diameter was significantly smaller in trefoil canals than in those of normal shape (p < 0.03). Since the measurement of trefoil shape is linked to the midsagittal diameter it compensated for the changes in AP dimension and underestimated the relation-
ship between the midsagittal diameter and the trefoil shape. We found correlations of 0.49 between trefoil shape and LRD ($p < 0.001$; Fig. 4) and of 0.84 between LRD and midsagittal diameter which are highly significant ($p < 0.001$; Fig. 5). There was no significant difference in interpedicular diameter between the two groups ($p > 0.5$).

No significant relationship was found between the trefoil shape and degeneration of the articular facets or osteophytes encroaching into the vertebral canal, although in a few cases when these conditions occurred together with trefoil configuration, they produced additional narrowing of the canal.

DISCUSSION

The trefoil shape of the vertebral canal can have troublesome clinical consequences; when the cross-sectional area is reduced by osseous narrowing there is relatively less room for soft-tissue structures. Thus, in the presence of disc protrusion, segmental displacement or the dynamic activity of extension the neural contents may be compromised in a small canal. Both a small midsagittal diameter and a trefoil shape can have clinical significance, particularly in combination (Fig. 6). Our study has shown that a small LRD is an essential constituent of the trefoil configuration and that there is a significant relationship between trefoil shape and small midsagittal diameter. There was no correlation, however, between the interpedicular diameter and trefoil shape. The midsagittal diameter matures at L5 in infancy while the interpedicular diameter increases in size up to adulthood. Thus although the trefoil shape is not apparent until adulthood it is probably programmed in early life.

There was a significant increase in the occurrence of trefoil shape until adulthood in this cross-sectional population, but no significant difference was detected above and below 40 years of age in adults, suggesting that trefoil shape is largely developmental and that any contribution from degenerative change is relatively small.

The aetiology of trefoil shape and developmental stenosis is not known. It has been suggested that infant malnutrition may be responsible for sagittal narrowness of the lumbar canal (Clark, Panjabi and Wetzel 1985; Porter and Pavitt 1987). There may be independent factors involved which can only be resolved by longitudinal and genetic studies.

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| Table 1. Mean midsagittal (MS) and interpedicular (IP) diameters (mm) and trefoil shape (TS) (percentage) in trefoil and non-trefoil canals according to age for 143 L5 vertebrae |
|---|---|---|---|---|---|---|---|
| Age (yr) | Trefoil (n = 29) | | | | Non-trefoil (n = 114) | | |
| | MS | IP | TS (%) | Number | MS | IP | TS (%) | Number |
| 1 to 10 | 14.73 | 24.61 | 59 | 3 | 15.74 | 18.97 | 92 | 27 |
| 11 to 20 | 12.09 | 24.17 | 62 | 4 | 14.84 | 22.57 | 77 | 14 |
| 21 to 30 | 15.01 | 24.22 | 51 | 2 | 15.73 | 23.96 | 78 | 15 |
| 31 to 40 | 14.93 | 25.30 | 60 | 5 | 14.95 | 23.20 | 76 | 15 |
| 41 to 50 | 15.02 | 26.10 | 56 | 7 | 15.19 | 24.28 | 75 | 15 |
| 51 to 60 | 14.09 | 24.91 | 60 | 8 | 24.93 | 75 | 13 | 15 |
| 61 to 70 | 22.50 | 26.10 | 56 | 7 | 15.19 | 24.28 | 75 | 15 |

Fig. 5

Graph showing a highly significant correlation between the lateral recess depth and the midsagittal diameter.

Fig. 6

The midsagittal diameter of the trefoil canal (left) is smaller than that of the normal canal (right).
REFERENCES


