THE THORACO-LUMBAR MORTICE JOINT

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INTRODUCTION

There are many recorded observations on the anatomy of the vertebral column. Much of this work has been done with comparative, and some with human, material. Amongst the detailed studies of the different regions in man are those of Humphry (1858), Holden (1861), Macalister (1889), Frazer (1940), and Slijper (1946), and a clear picture has been drawn of the anatomy and functions of the thoracic and lumbar regions as separate units.

The thoraco-lumbar junctional region has, however, received less attention. Humphry stated that the lower two dorsal and upper one or two lumbar vertebrae were the weakest part of the column, a view endorsed by Holden. Macalister stated that the point most exposed to injury was the union of the dorsal and lumbar curves. These three authors suggested that this vulnerability was due to the junction of the relatively immobile thoracic column with the mobile lumbar region. In addition, Humphry suggested that the bodies of these vertebrae were relatively too small to bear the weight upon them, that the transverse and spinous processes were too short to give adequate muscular support, and that the position of the region within the middle of the column exposed it to maximum leverage from above and below. No supporting evidence was given for these views, however, nor were these various factors collated in individual columns. A report of a further study of the osteology of this portion of the vertebral column is, therefore, justifiable.

MATERIAL

Out of a series of 149 dry adult human vertebral columns, sixty-nine were chosen for this study since they were free from artefacts and pathological changes. Twenty-two younger specimens, both dry and cartilage covered, were also studied. Their ages ranged from full term to 20 years. Not all these younger specimens were complete columns, but all used for this investigation had at least the lower eight thoracic and upper four lumbar vertebrae. Five fresh adult specimens of the lower thoracic and upper lumbar region were used to study movements, one from a female of 21 years, the others from males of 33, 34, 34 and 36 years respectively.

METHODS

The configuration of the articular processes was carefully noted in all specimens. In fourteen columns the areas of the upper surfaces of the vertebral bodies were measured. Their outline was traced on to standard six-sheet card and this outline was cut out and weighed, its area being calculated from the known weight-to-area relationship of the card. In the same fourteen columns pedicle thickness was assessed by measuring with callipers the greatest and least diameters of the most slender portion of the pedicle. These two figures, in millimetres, were then multiplied together, and the product termed the *pedicle index*. This index is, therefore, a rough guide to the cross-sectional area of the pedicle at its most slender part. In all columns, particular attention was paid to the markings on the laminae.

OBSERVATIONS

Articular processes

In sixty-seven of the sixty-nine adult columns, one zygapophyseal joint at the thoraco-lumbar transitional region differed markedly from those above and below it. Processes of the lower participating vertebra combined to form a structure comparable with a carpenter's mortice (Pl. 1). The mortice was bounded anteriorly by the two superior articular processes, laterally by the combined transverse and mammillary processes (superior tubercles), and posteriorly by the overhanging mammillary processes alone. The lateral walls were closer to each other below than above. The tenon consisted of the inferior articular processes of the upper vertebra together with their connecting laminae, and was also narrower below than above.

In the twenty-two juvenile columns no evidence of the mortice was seen in the four below the age of 2 years, but it was found in sixteen of the remaining eighteen, including one aged 2 years and 8 months.

The level of the mortice joint was found to vary, but in the adult series was commonest between the eleventh and twelfth thoracic vertebrae:

Level of mortice joint	No. of columns
T 10–11	5
T 11–12	46
T 12–L 1	16
Total	67

(No figures are given for the level of the joint in the juvenile series as some of the columns were incomplete.)

In every case of both series the joint above the mortice was of the thoracic type, and that below it, lumbar. In the remaining six columns without a mortice, the twelfth thoracic vertebra had superior articular processes of a thoracic type, the inferior processes being of lumbar morphology.

The mortices varied in depth, and could be divided into three groups (Pl. 1). In the first of these, the lateral wall of the mortice fully enclosed the tenon, in the second it was less extensive but enclosed more than half, and in the third, less than half. The results were as follows:

	Adult	Juvenile
Group I	8	1
Group II	32	8
Group III	27	9
No mortice	2	4
Total	69	22

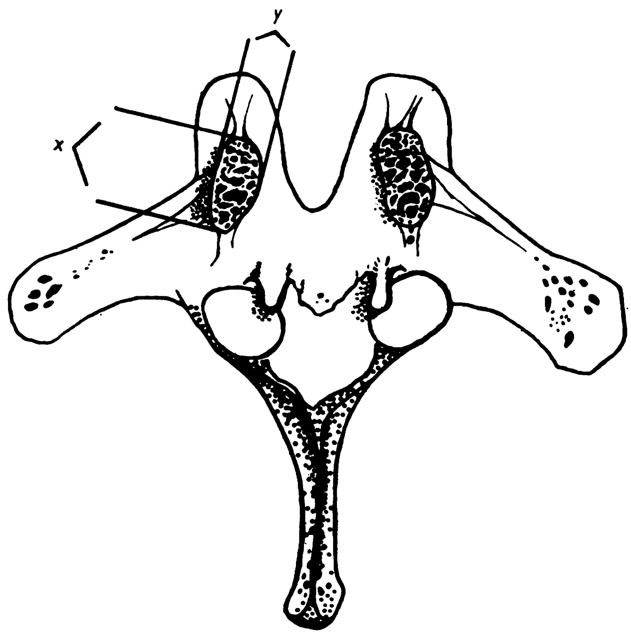
In groups I and II the articular surface spread on to the lateral walls for a varying distance; in group III it was restricted to the anterior wall. The extent of the articular surfaces of the tenons varied accordingly.

In the wet specimens, a very small movement of the tenon vertebra was sufficient to lock the tenon into the mortice, thus preventing all movement other than flexion. If, with the mortice locked, a strong vertical compression force was applied to the vertebrae, the only movement was one of flexion; whereas at the thoracic or lumbar joints, the same force caused the vertebral bodies to approach each other slightly as the disc compressed, but without any other movement.

Planimetry

The areas of the upper surfaces of the bodies of the thoracic and lumbar vertebrae were measured in ten adult and four juvenile columns.

A similar configuration was found in every column, that is, the areas increased slowly in the upper thoracic region, and then rapidly to the mortice vertebra, and



Text-fig. 1. A diagram of the ventral surface of the neural arch of a thoracic vertebra. The pedicles were cut transversely at their waist. Pedicle index = xy (in mm.).

more slowly thereafter. The greatest rate of increase occurred in the mortice vertebra and those immediately above it, irrespective of the position of the mortice within the column.

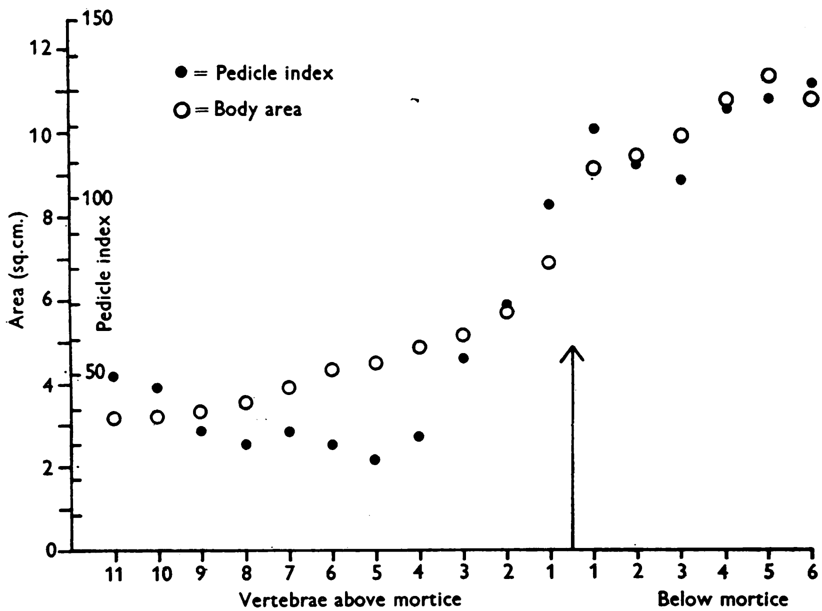
Pedicle index

In the same fourteen columns, the pedicle indices were calculated for one pedicle of each thoracic and lumbar vertebra. In eight columns the pedicles of the right side were measured, in six, those of the left side (Text-fig. 1). In all columns the findings were similar. There was a fall in the upper thoracic region, a rise below this, with a sudden large increase as the mortice was approached and reached (Text-fig. 2). Below the mortice the index usually decreased slightly.

The laminae

In all columns the ventral surfaces of certain laminae bore a spicule or spur of bone within the marking for the upper attachment of the ligamentum flavum. These spicules sprang from the lateral part of the marking, and pointed inferiorly (Text-fig. 3).

In most columns they were present in several successive vertebrae, increasing in size from above downwards. The largest seen in this series were 5 mm. long, and 4 mm. wide at their base. The number and distribution of these spicules is shown



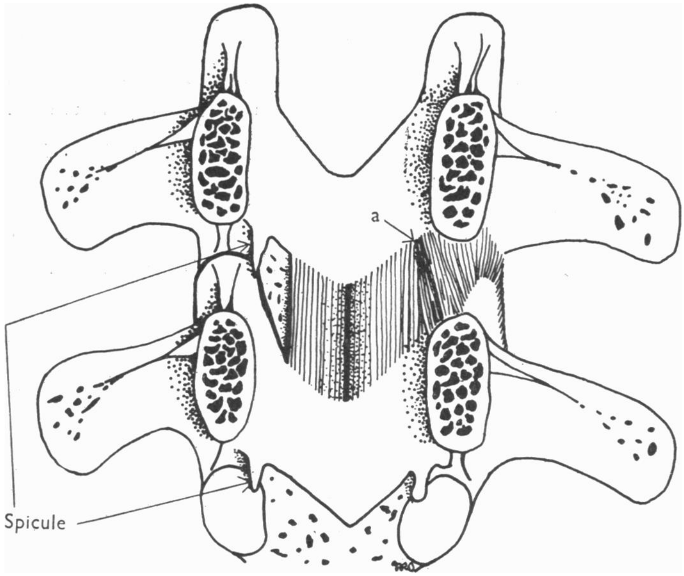
Text-fig. 2. The areas of the upper surfaces of the vertebral bodies, and the left pedicle indices, of a male adult vertebral column. The arrow marks the position of the mortice joint.

(Text-fig. 4) as a histogram, the vertebrae being numbered from the mortice joint, whence it can be seen that the spicules occurred with increasing frequency down to that level, and were but rarely present below it.

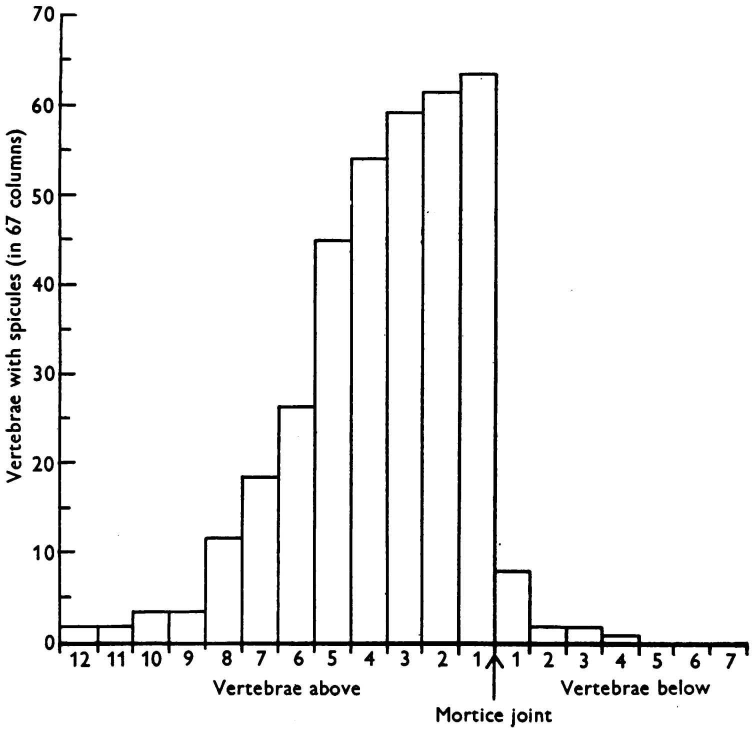
In this series the youngest column possessing these spicules was from a girl of 16 years, and spicules were also present in columns of 18, 20 and 21 years.

DISCUSSION

Since the mortice joint intervenes between two series of zygapophyseal joints manifesting respectively thoracic and lumbar structural characters, it is reasonable to consider it as marking the junction of two functionally different regions of the spinal column. It is important to note that it may be placed above the lowest rib-bearing vertebra.



Text-fig. 3. A diagram of the ventral surfaces of the neural arches of two lower thoracic vertebrae. The ligamentum flavum and capsular fibres of the zygapophyseal joint are shown. *a*, the position of the spicule within the junction of the oblique capsular and the vertical flaval fibres.



Text-fig. 4. A histogram showing the frequence of laminar spiculation in sixty-seven adult vertebral columns.

It has been shown that, with the mortice locked, a compressing force, which is prevented by the lock from forcing the tenon downwards, must cause flexion of the joint, by compressing the intervertebral disc. This compression must raise the pressure within the nucleus pulposus, and hence increase the pressure on the vertebral bodies of the mortice vertebra and those below it.

The progressive increase in area of the vertebral bodies from above downwards must reflect the increasing load borne by each successive vertebra, realizing that this load is made up of the body weight, and any additional weight borne by the upper part of the body. In addition, the leverage that this load can exert on the individual thoracic and lumbar vertebrae increases steadily down to the pelvis. (In three of the fourteen columns measured, the last lumbar vertebra had an area somewhat less than that of its fellows (Text-fig. 2), together with large transverse processes. It seems probable that, in these, rather more weight than usual was carried by the ilio-lumbar ligaments.)

It is suggested that the marked increase of body area, related constantly to the level of the mortice, is a necessary reinforcement to sustain the great increase in pressure caused by the locked and flexed mortice joint. This compressing force will also tend to shear the neural arch from the body of the vertebra. The consequent need for reinforcement of the pedicles is reflected by their great increase in thickness.

The spicules found upon the ventral surfaces of the laminae have been described by Shore (1931) in the Bantu, and by Allbrook (1954) in East Africans. In this series they were found in every normal adult, and in several young, columns. They were of smooth bony structure, and appeared to be integral parts of the vertebrae, in no way resembling exostoses. These findings strongly suggest, but do not prove, that they are normal anatomical structures. Le Double (1912) thought that they were vestiges of zygosphenes, but the observations of Naffziger, Inman & Saunders (1938) refute this, for in their studies on the ligamentum flavum they found that the spicules lay within the ligament, at the point where its fibres intermingled with the obliquely placed fibres of the capsule of the zygapophyseal joint (Text-fig. 3). These oblique fibres are tightened by, and limit, thoracic axial rotation. The distribution of the spicules suggests that this limitation is greatest just above the mortice joint, the mortice itself allowing no rotation at all when locked.

In industrial accidents, crush fractures of the vertebral bodies most frequently involve the twelfth thoracic or first lumbar vertebra (Jefferson, 1927; Nicoll, 1949; Newman, 1952). These injuries are frequently caused by the descent of a large weight upon the head and shoulders of the individual, imposing a vertical compression force upon the vertebral column from above. In a large series of American parachuting injuries, Ciccone & Richman (1948) found that the majority of crush fractures also involved the twelfth thoracic and first lumbar bodies, hard falls in the upright posture imposing a vertical compression force from below. At a British parachute training establishment, the present author found that, of seven cases of crush fracture recorded, those four who had sustained large vertical deceleration had crushed the bodies of either the twelfth thoracic or first lumbar vertebrae. Such a distribution of fractures can be explained by the great increase of pressure that must follow the forced flexion of the locked mortice joint when such compression forces are applied.

SUMMARY

The region of functional transition between the thoracic and lumbar regions of the human vertebral column is commonly marked by a type of zygapophyseal joint comparable with a carpenter's mortice. The areas of the vertebral bodies and the size of the pedicles increase most rapidly in this region. Laminar spicules within the ligamenta flava have a distribution which is related to the level of the mortice. The functional significance of these findings is discussed.

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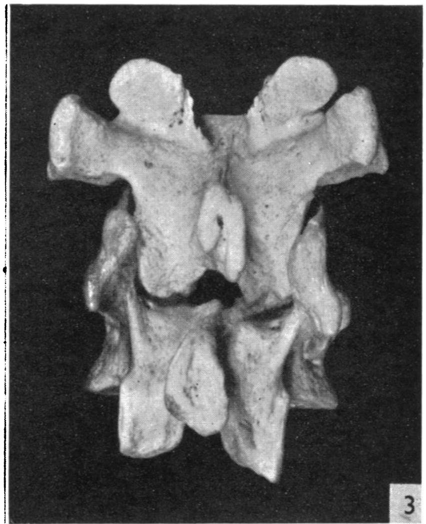
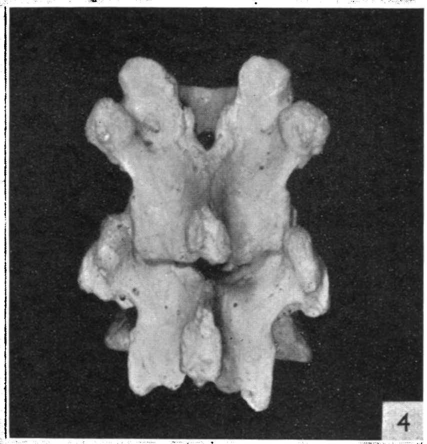
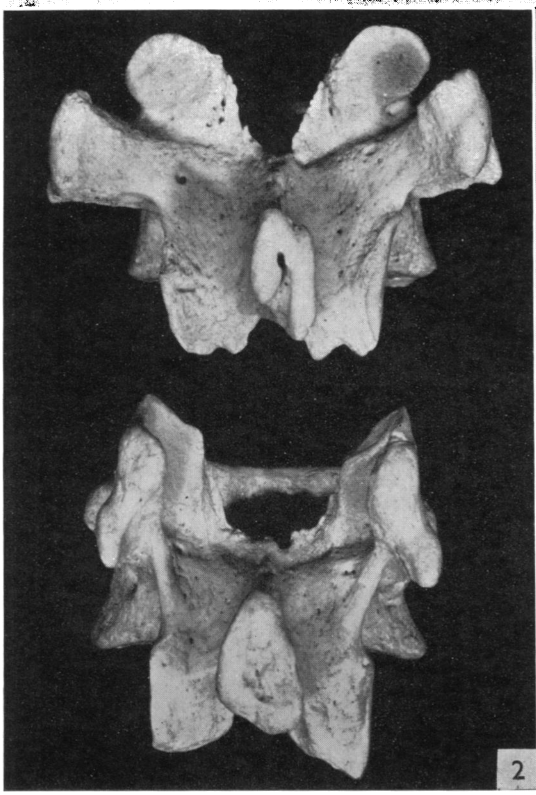
EXPLANATION OF PLATE

Fig. 1. Superior view of a twelfth thoracic vertebra from a male adult, showing the components of a group I mortice. The mammillary processes overhang the joint cavities posteriorly; their roots, together with the roots of the transverse processes, form the lateral walls, and anteriorly the articular processes are seen. The lateral walls approach each other in the lower, deeper, parts of the mortice. The articular surface lines all three walls.

Fig. 2. A dorsal view of the eleventh and twelfth thoracic vertebrae, from the same column as fig. 1. The tenon, formed by the inferior articular processes of the eleventh thoracic vertebra and their connecting laminae, is narrower below than superiorly. The mortice in the lower vertebra shows the overhang of the mammillary processes.







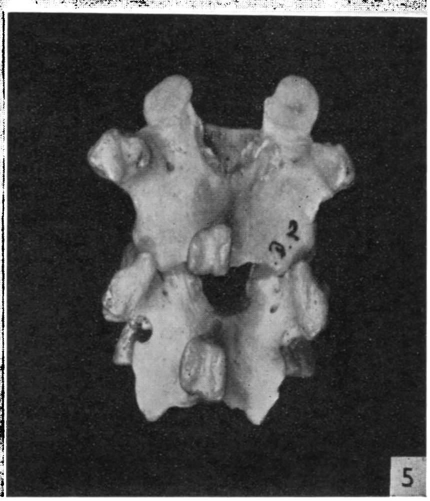


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Fig. 3. Dorsal and lateral views of the eleventh and twelfth thoracic vertebrae of a male adult, showing a group I mortice (the same vertebrae as in fig. 1). The inferior articular processes (tenon) are fully enclosed laterally by the mortice of the lower vertebra.

Fig. 4. The tenth and eleventh thoracic vertebrae of a female adult, showing a group II mortice. Half of each of the inferior articular processes of the upper vertebra are enclosed laterally by the mortice.

Fig. 5. The eleventh and twelfth thoracic vertebrae of a male adult, showing a group III mortice. Only the lowest parts of the inferior articular processes of the upper vertebra are enclosed laterally by the lateral wall of the mortice.