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Short Report

Changes in the surface of the superior articular joint from the lower thoracic to the upper lumbar vertebrae

HARAMUCHI SHINOHARA

Division of Human Sciences, Faculty of Medicine, Toyama Medical and Pharmaceutical University, Japan

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ABSTRACT

Thirty-two human vertebral columns were selected from the Kanazawa Collection at the University of Kanazawa, Japan. The superior articular joint surface was categorised into the thoracic type and the lumbar type, and the pattern of the change from one type to the other in the lower thoracic and upper lumbar region was examined. In 21 of 32 cases (66%), the change from the thoracic to the lumbar type occurred over 2 vertebral segments, either between the 12th thoracic and 1st lumbar vertebrae (44%) or between the 11th and 12th thoracic vertebrae (22%). In the remaining 11 cases (34%), the change occurred over 3 vertebral segments, with a transitional type of articular surface. The change from the thoracic to lumbar type of articular surface has been believed to occur over 2 vertebral segments, but occurs over 3 segments in as many as 34% of the articular surfaces.

Key words: Human vertebral column.

INTRODUCTION

In individuals with cervical ribs, the 7th cervical vertebra articulates with the ribs and provides the costal joints on the vertebral body and transverse processes (Struthers, 1875; Barclay-Smith, 1911). Similarly, in those with lumbar ribs, the 1st lumbar vertebra provides the joints with the ribs (Struthers, 1875). These variations, although they occur rarely, suggest that one of the structural elements in formation of the vertebrae, namely, the costal joint is susceptible to forward or backward displacement. A century ago, Bateson (1894) referred to the movement of a structural element in the cranial direction as 'backward homeosis' and to that in the caudal direction as 'forward homeosis' and he predicted the presence of genetic causes underlying homeosis. The backward and foward homeosis correspond to the posterior and anterior transformations that occur in gene targeting of Hox genes (Lewis, 1978; Jegalian & DeRobertis, 1992). The transformations are known to occur heterogeneously among the structural elements of a vertebra and even one structural element may consist of different groups of precursor cells each of which expresses different combinations of Hox genes (Kostic & Capecchi, 1994). These observations suggest that changes of morphology from one vertebra to another do not occur uniformly in all structural elements. There may be some structural elements for which morphological change is loosely determined and in which variations commonly occur, while the presence of other structural elements, such as the costal joint surface, is rigidly restricted and in which change occurs very rarely.

With the working hypothesis that all structural elements that form the vertebrae can move along the long axis of the body to a greater or lesser extent, a survey was made of the human vertebral column. The joint surfaces of the superior articular processes were observed to change their shape and orientation in a manner that differed from that which has been previously accepted.

Correspondence to Dr Haramuchi Shinohara, Division of Human Sciences, Faculty of Medicine, Toyama Medical and Pharmaceutical University, Sugitani 2630, Toyama 930-01, Japan.

MATERIALS AND METHODS

Thirty-two human vertebral columns were selected from the Kanazawa Collection at the University of Kanazawa, Japan. The age of subjects ranged from 15 to 81 y; 18 were male, 8 female, and 6 undocumented. They were mostly Japanese, but included 3 members of other East Asian races.

The articular surfaces of the superior articular processes were divided into thoracic and lumbar types. The articular surface of the thoracic type was flat and oriented dorsolaterally, while the articular surface of the lumbar type was concave and oriented dorsomedially (Fig. 1). Observations were made to determine the change of the mode from the thoracic type to the lumbar type in the lower thoracic and upper lumbar vertebrae.

RESULTS

There were 6 patterns of change (see Table). In 21 of 32 cases (66%), the change from the thoracic to the lumbar type occurred over 2 vertebral segments, either between the 12th thoracic vertebra (T12) and the 1st lumbar vertebra (L1) (44%, Fig. 2*A*) or between T11 and T12 (22%). In the former instance, for example, the inferior articular surface of T12, which was convex and oriented ventrolaterally, was congruent with the lumbar type of articular surface of L1. In the remaining 11 cases (34%), the change in the articular surface occurred gradually over 3 vertebrae; a transitional type of articular surface was interposed between the typical thoracic and lumbar types of surface (Fig. 2*B*, *C*). The thoracic type of surface accounted for 100% of surfaces at T11, with the percentage decreasing at T12 and L1, and becoming zero at L2. By contrast, the lumbar type of articular

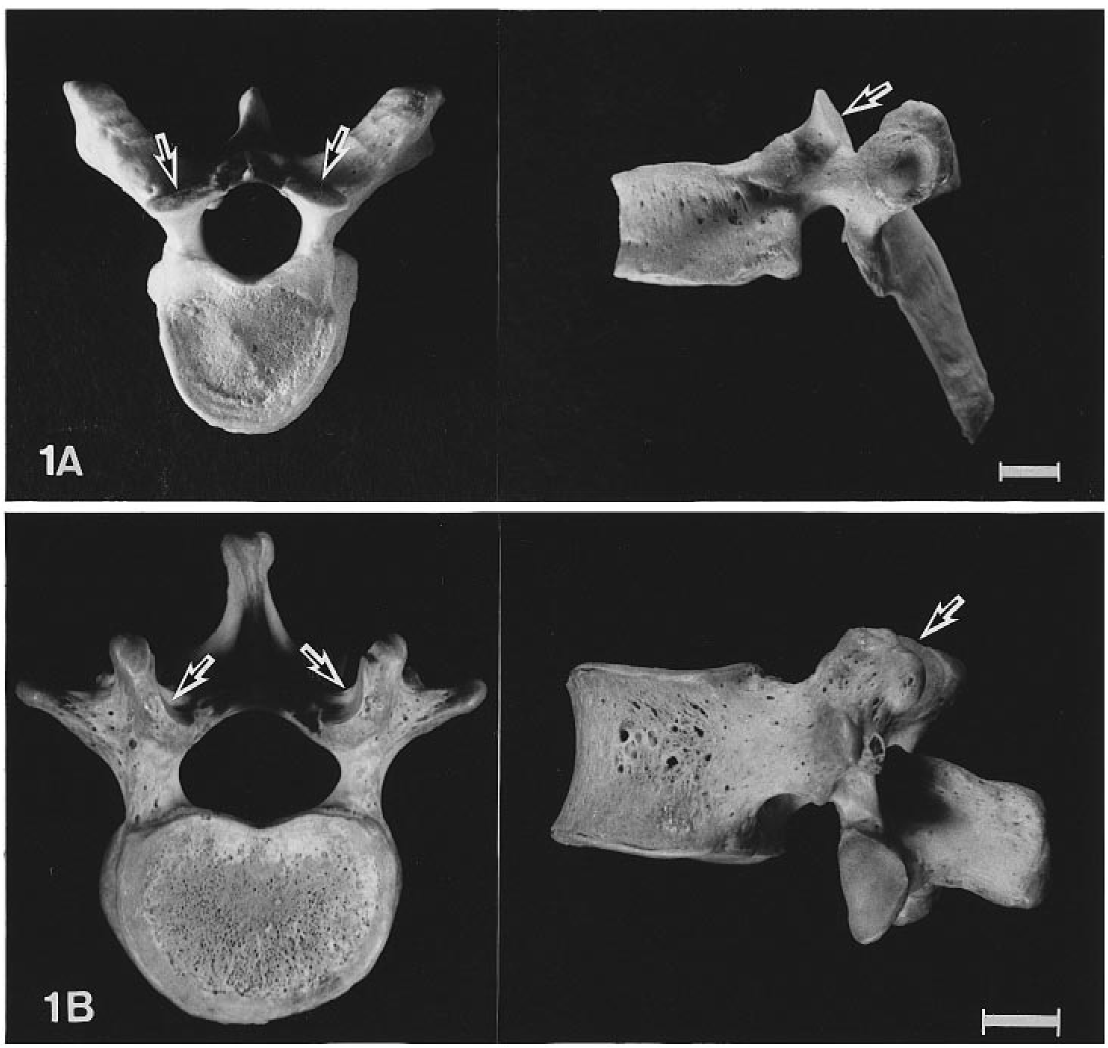
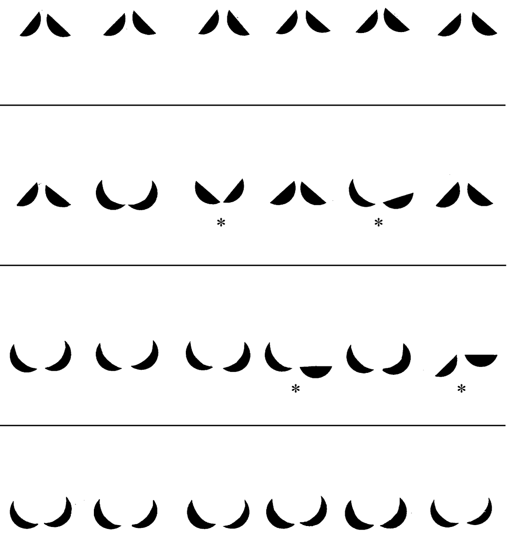


Fig. 1. The 2 types of superior articular surface. The thoracic type of surface (A) is flat and faces dorsolaterally (arrows), while the lumbar type of surface (B) is concave and faces dorsomedially (arrows). Bar, 1 cm.

Table. *Patterns of change from the thoracic of the lumbar type of articular surface*



	Changes over 2 segments 21 (66)		Changes over 3 segments 11 (34)			
	14(44)	7(22)	4(13)	3(9)	3(9)	1(3)
T11 F (100) C (0) DL (100) DM (0)						
T12 F (73) C (27) DL (56) DM (44)			*		*	
L1 F (8) C (92) DL (2) DM (98)				*		*
L2 F (0) C (100) DL (0) DM (100)						
Age range (y)	16–81	19–80	23–67	15–78	72, 81	23
Males	9	4	2	1	1	1
Females	2	2	1	2	1	0
Number of un-documented cases	3	1	1	0	1	0

* The 32 specimens revealed 6 patterns of change. Note that the surface characteristics and orientations are not always identical on the right and left sides. The number within parentheses are percentages and those without are the numbers of cases. The abbreviations in the vertical column signify surface characteristics and orientations of the articular surface, i.e. flat (F), concave (C), dorsolaterally oriented (DL) and dorsomedially oriented (DM). The asterisks indicate transitional types of articular surface.

surface accounted for 0% of surfaces at T11 and 100% at L2.

In the thoracic type of articulation, the superior articular surface of a vertebra was covered by the inferior articular surface of the upper vertebra but its inferior articular surface covered the superior articular surface of the lower vertebra (Fig. 3). Similarly, in the lumbar type of articulation, the superior articular surface of a vertebra encapsulated the inferior surface of the upper vertebra but its inferior articular surface was encapsulated by the superior articular surface of the lower vertebra (Fig. 3). With the change from the thoracic to the lumbar type of articulation, therefore, both the superior and inferior articular surfaces were covered by the articular surfaces of the adjacent vertebrae. The alteration in the cover and covered relationship occurred at T12 or L1.

DISCUSSION

There were 6 patterns in the change of the superior articular surface from the lower thoracic to upper lumbar vertebrae, but these do not include all possible combinations of change. If greater numbers of specimens were observed, more patterns would probably be disclosed. One or 2 females were always present in 5 out of the 6 patterns, and the distribution of ages was almost identical in the changes both over 2 and 3 segments; age and sex therefore do not seem to show preferential patterns. The percentage of the changes over 3 segments was 34% in East Asian races but may be different in other races. This possibility should be examined in greater numbers of specimens of various races.

According to Williams et al. (1989; see also Davis, 1955) the change in orientation of the articular process from the thoracic type to the lumbar type usually occurs at the 11th thoracic vertebra, but sometimes at the 12th or 10th. The change was described as sudden, occurring over 2 vertebral segments. The present results do not conform to this description. First, the change occurred most frequently at the 12th vertebra (44%), twice as frequently as the 11th (22%). Secondly, a sudden change from the thoracic to the lumbar type occurred in more than half of all cases (66%), although 34% of the articular surfaces showed a gradual change with a transitional type of articular surface over 3 vertebral segments.

There is general agreement that the primary function of the articulations between the vertebral bodies is load-bearing, while that of the articulations between the articular processes is the limitation of the direction and extent of trunk movement. Unquestionably, however, the articular processes also play a load-bearing role, even though such a role complements that of the vertebral bodies. In the thoracic as well as in the lumbar vertebrae, part of the load on the articular process is transmitted and distributed to the adjacent vertebrae, resembling the situation in regularly laid roof tiles among which pressure is transmitted and distributed through overlapping. In the vertebra at which the change occurs, T12 or L1, the situation is somewhat different; the regularity of the overlap between the tiles is lost. In industrial accidents (Jefferson, 1927; Nicoll, 1949)

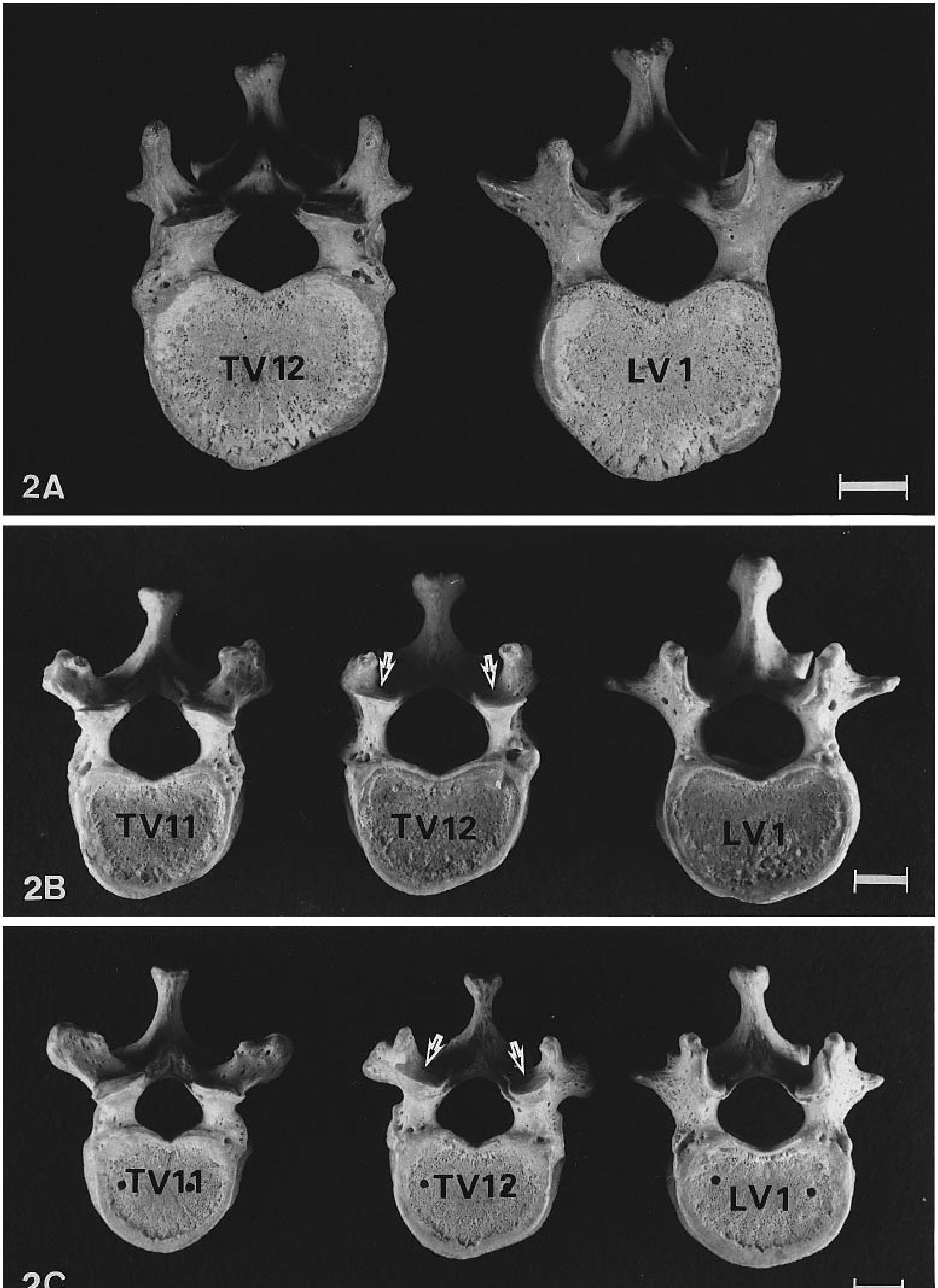


Fig. 2. Sudden and gradual changes in the articular surface. The sudden change occurs at 2 vertebral levels (*A*). For gradual changes (*B*, *C*), a transitional type of surface, intermediate between the typical thoracic and lumbar types, is found (arrows). Thus the change occurs at 3 vertebral levels. Bar, 1 cm.

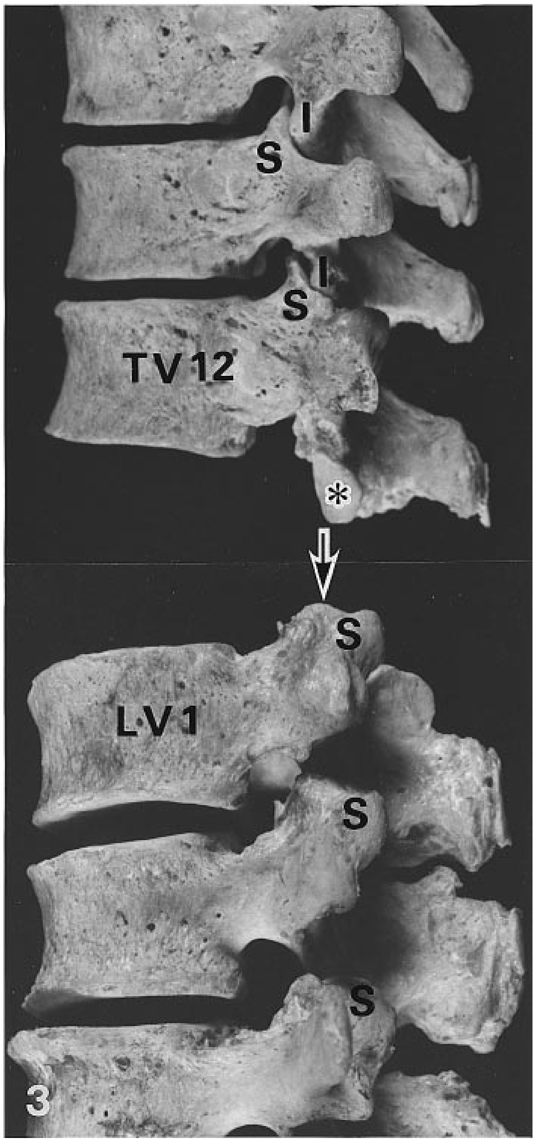


Fig. 3. The cover and covered relationships of the superior and inferior articular surfaces from the lower thoracic to the upper lumbar vertebrae. Note that both the superior and inferior articular surfaces of the 12th thoracic vertebra are covered by the adjacent articular surfacs. The cover-covered sequences in both the thoracic and lumbar vertebrae are interrupted at this vertebra. The asterisk indicates the convex inferior articular surface that is to be covered by the superior articular surface of the next vertebra (arrow). S, superior articular process; I, inferior articular process.

and in parachuting injuries (Ciccone & Richman, 1948), the 12th thoracic vertebra or the 1st lumbar vertebra are the most frequently involved. Davis (1955) thought that this greater frequency of involvement might be related to the change in the articular surface of the superior articular process. He suggested that movements of the vertebra at which the change occurs might be more rigidly restricted than those of the other vertebrae and that this immovability might cause crushing when pressure for forced flexion is applied. The present author agrees with this view but proposes in addition another possibility, namely, that the articular processes of the vertebra at which the change occurs do not adequately share the load with the vertebral body and, consequently, the load at this vertebra is borne exclusively by the body and tends to crush it.

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