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EXPERIMENTAL PROGRESSIVE SCOLIOSIS IN A PIG

By

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INTRODUCTION

In spite of many years of clinical and experimental investigation the biological cause of juvenile idiopathic scoliosis is still unknown. The early appearance of the syndrome "idiopathic scoliosis", often during the first year of life, is stated to be a characteristic one. With few exceptions idiopathic scoliosis is progressive, resulting in disablements with compensatory rebuilding of the vertebral column.

Scoliosis has been produced experimentally in animals, but the induced injury was applied to different sites and degrees in the vertebrae, and changes corresponding to those in juvenile scoliosis in man were not been demonstrated.

Knutsson has suggested a theoretically sound hypothesis of its cause and progress based on a survey of experimental work. He pointed out the dualistic development of the vertebra during normal growth.

By analogy with the bones of the extremities the vertebral bodies grow during the whole period of development of the individual. In man this growth is not complete until the age of 18 to 20 years. By analogy with the cranium the vertebral arch grows rapidly from the ages of 3 to 5 years, but already by the age of 1 year the two arches are united by bone. The growth then takes place only in the neuro-central junctions towards the vertebral body and is complete at the age of 10 years.

As a result of this the symmetry of the vertebral arch is due to equal growth of the two neuro-central junctions towards the vertebral body. If this growth proceeds asymmetrically during the first decade because of premature closure of the neuro-central junction, ventral displacement of the vertebral body on this side does not occur. The arch on the opposite side grows, however, and like a train buffer dislocates the part

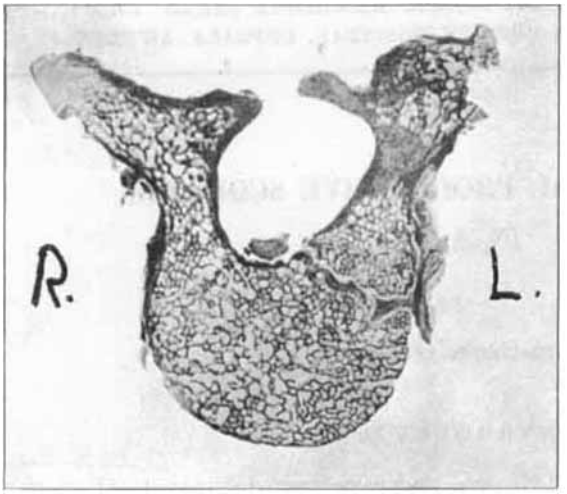


Fig. 1.
Assymetrical growth of Th 8 from child with a scoliosis to the right. Fused neuro-central junction on the convex side, open on the concave side. The vertebral body rotated towards the convexity. (Taken from Nicoladoni's publication).

of the vertebral body in front, which is thus rotated ventro-contralaterally (*Schede-Knutsson*).

This asymmetry in development of the vertebral arches and malrotation of the vertebral bodies was described in anatomical studies of scoliotic vertebrae from postmortem material in infantile scoliosis (*Nicoladoni*). Four cases: 1, 6, 6½ and 7 years of age are described. The following common changes in the scoliotic vertebrae are found (Fig. 1):

1. The development of the neuro-central junctions was asymmetrical. Well developed and completely open neuro-central junctions were found in the concavities of the scolioses. In the convexities of the scolioses the junctions were thinner (1, 6 years of age), and there appeared interruptions in continuity-synostoses (6½, 7 years).

2. The arches in the concavity were long and fine, whilst those on the convexities were short and irregular.

3. The vertebral bodies were rotated towards the convexity of the scolioses with the centre of rotation in the ossified neuro-central junction.

Thus the vertebral bodies are forced out of their static relationship with those above and below, and are rotated laterally. The resulting scoliosis is combined with a lordosis because of changes in the loading conditions. Later they are secondarily distorted in the scolioses (*Sommerville*).

Premature closure of one neuro-central junction resulting from injury may explain the initial phase of infantile scoliosis. The resulting

changes in loading would then produce secondary compensatory curvatures as a normal biological response.

OPERATIVE PROCEDURE AND RESULTS

As mentioned in the introduction, injuries to the vertebral arches, processes and bodies have been carried out in animals (*Haas, Langenskiöld, Moser, Pacher, Roaf*). However, the neuro-central junctions were unintentionally involved either partially or completely by these procedures.

In the following, an account is given of unilateral, experimental injury to the neuro-central junction in an isolated lumbar vertebra of the pig. For technical reasons, experiments were carried out in the lumbar region. The vertebrae of a pig are well developed in this region, and growth is rapid during the first months of life. The vertebral arches are wide and easy of access.

Using a rotating dental drill with a diameter of ½ mm. a unilateral neuro-central junction was injured in a 28 day old pig. A para-vertebral incision was made and the drill was inserted to a depth of ½ cm. into the right neuro-central junction in the caudal part of L2 without da-

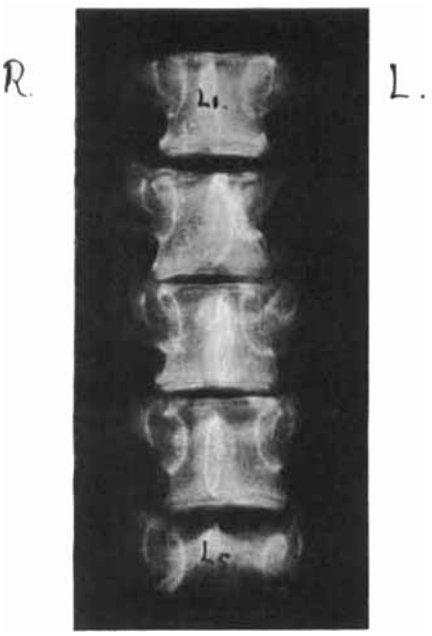
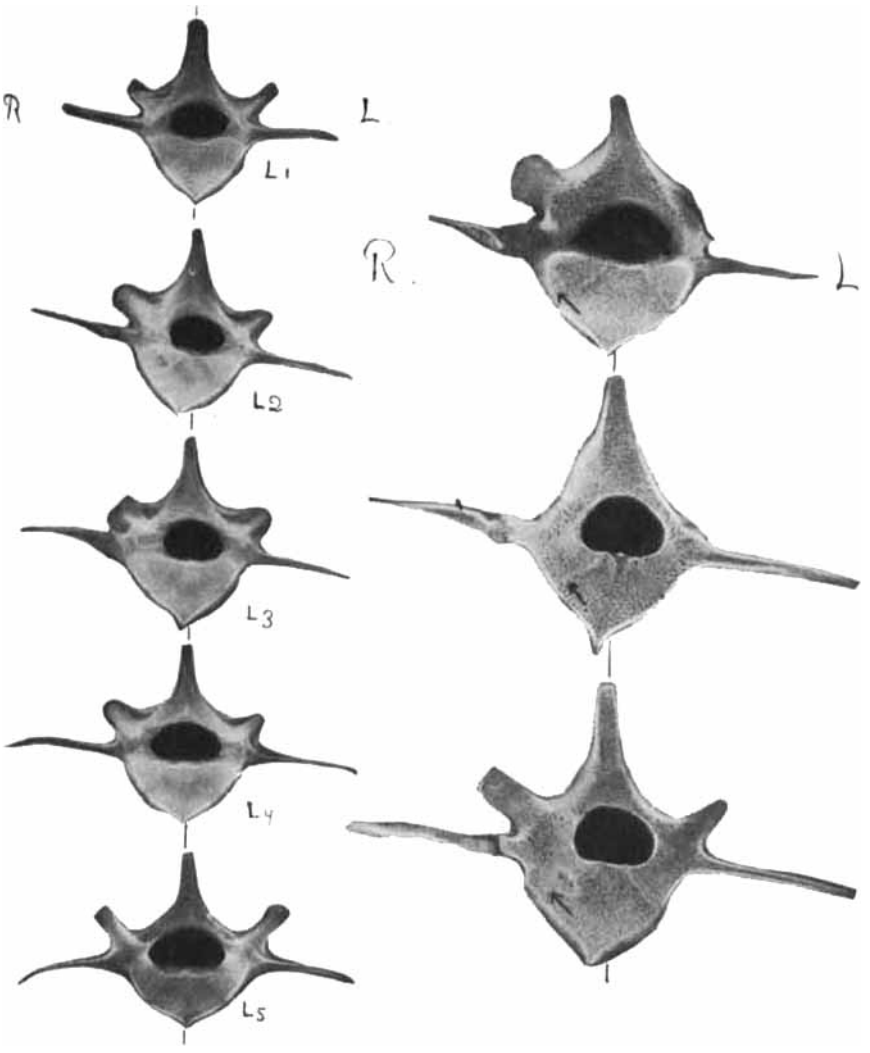


Fig. 2.
Frontal radiogram L_1–L_5 from pig 3 months of age. A slight scoliosis with the convexity to the rigth is seen after an isolated injury to the right neuro-central junction of L_2.



Figs. 3.
L_1–L_5 from the same pig as in Fig. 2. The vertebral bodies rotated to the right in L_1–L_4 and the right arch is short and irregular.

Fig. 4.
L_2, cut in horizontal slices, from the same pig as in Fig. 2–3. Fusion of the injured right neuro-central junction in its lateral region. Short, irregular arch on this side. The vertebral body rotated to the right.

mage to the L2–L3 disc. The drill was then moved cranially and bored a canal within the junction. It was removed before reaching the L1–L2 disc. The L2 vertebra was marked with a small wire suture at the tip of the spine, and the wound was then closed.

After three months the animal was killed, the increase in weight during this time being 32 kilos (8–40). The lumbar vertebrae were dissected out and a frontal radiogram was taken (Fig. 2). On this is seen a slight scoliosis, convex to the right involving the whole lumbar region but without a centre of rotation. The vertebrae L1–L5 were then dissected free, and the architecture was studied roentgenologically (Fig. 3). Not only did the operatively injured L2 vertebra show pathological changes but also L1, L3 and L4 showed common specific changes. In the convexity of the scoliosis the arches are irregular and short, whilst the opposite concave ones are fine and longer. Except for L2 the neuro-central junctions are completely visible and roentgenologically equal. For more detailed studies of vertebra L2 it was necessary to cut horizontal slices, 2–3 mm. thick, which are shown in the radiogram (Fig. 4). Besides the above-mentioned changes the neuro-central junction on the convex side was affected. In the most caudal slice a small defect could be seen corresponding to the site of the drill during the operation. In the next two slices there was a fusion in the lateral half of the neuro-central junction and growth had ceased. The medial half of the neuro-central junction can still be clearly seen.

DISCUSSION AND CONCLUSIONS

As described above, the scoliosis produced surgically in the pig corresponds closely to infantile scoliosis in man (*Nicoladoni*). The damage to the neuro-central junction of L2, followed by premature fusion, produced an asymmetrical growth of the arch with a secondary rotation of the vertebral body towards the fused side. The disturbance in static relations hereby produced reacted biologically on the surrounding vertebrae, distorting them. The results obtained from an isolated unilateral unjury to one neuro-central junction, reported here, encourage further experimental investigation, e.g. with apes, where the loading relationships in the vertebral column correspond to those in man. If it can be shown that scoliosis similar to the above-performed experiment can be produced, progress of the scoliosis could possibly be stopped by a new operation on the other neuro-central junction before the neuro-central junctions are united.

SUMMARY

The neuro-central junction on one side of a lumbar vertebrae of a month old pig was injured by drilling. During the following 3 months a slight scoliosis developed in the lumbar spine. A premature fusion occurred in the injured junction associated with asymmetrical growth of the vertebral arch and rotation of the vertebral body towards the fused side. These findings are similar to the changes which have been found in juvenile scoliosis of homo by Nicoladoni.

RESUME

Chez un porc âgé d'un mois, il a été opéré par forage une lésion unilatérale de la jointure de l'arc d'une vertèbre lombaire. Au bout de trois mois, on a pu constater une scoliose marquée de la colonne lombaire. Dans la vertèbre, on trouva une fusion prématurée de la jointure de l'arc endommagé, une croissance asymétrique de l'arc vertébral et une rotation du corps de la vertèbre du côté de la fusion. Ces modifications sont conformes à celles constatées par Nicoladoni dans la scoliose juvénile humaine.

ZUSAMMENFASSUNG

Bei einem einen Monat alten Schwein wurde durch Bohrung auf einer Seite die Knorpelfuge in einem Lendenwirbel beschädigt. Nach drei Monaten trat eine angelentete Skoliose innerhalb der Lendenwirbelsäule auf. Bei diesem Wirbel fand man eine vorzeitige Verknöcherung in der einen beschädigten Knorpelfuge, asymmetrisches Wachstum des Wirbelbogens und eine Rotation des Wirbelkörpers nach der Verknöcherungsseite. Die Veränderungen stimmen mit denen überein, die bei juveniler Skoliose beim Menschen von Nicoladoni beschrieben worden sind.

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