

STUDIES ON THE PATHOLOGY OF THE LUMBOSACRAL DISC IN FEMALE CATTLE

By

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INTRODUCTION

There are no systematic studies on discs in cattle to be found in the literature. As far as animals are concerned, the interest in the pathology of the discs has especially centered on those of the dog, which were first subjected to study by *Dexler* as early as in the last decades of the 19th century. As for human pathology, attention was drawn to pathologic processes in the discs by *Schmorl* (1928), and the first earnest advocates of a common connection between disc prolapse and sciatica were *Mixter* and *Barr* (1934). Comprehensive studies on disc degeneration and disc prolapse in dog have been warranted by the great clinical importance of this phenomenon and by the fact that they must be of a certain interest to comparative pathology (*Olsson* 1951, *Hansen* 1952, *Olsson* and *Hansen* 1952, *Hoerlein* 1953, *Lindemann* and *Kuhlendahl* 1953, *Töndury* 1953, *Smith* and *King* 1954, *King* and *Smith* 1955).

From obvious reasons orthopedic ailments in cattle have not been given the same attention as those in e.g. horse or dog. However, an exception must be made for the serving inability in bull, which has partly been studied with a view to changes in the lumbosacral region (*Forssell* 1935, 1940, *Newton* 1941, *Böhler*, *Gjestvang* and *Slagsvold* 1951, *Bane* 1954).

The impulse to study the discs in cattle more closely was given me by the work of *Böhler et al.* They described lumbar spondylosis and/or protrusion of the lumbosacral disc in Norwegian bulls suffering from serving inability. An introductory study on the lumbar spine in cattle belonging to the autopsy material of our department showed characteristic degenerative processes and annulus ruptures, especially in the

The author wishes to express his gratitude to Dr. A. Pott of the Uppsala abattoir for his kind cooperation when specimens were taken and to Associate Professor S.-E. Olsson for assisting in the interpretation of the radiographs.

lumbosacral disc, in middle-aged and old cows (*Hansen 1952*). These cases had been subjected to post-mortem for various reasons and were not accompanied by anamnestic data on any back troubles observed. Also, changes of the type mentioned above were found in a bull that had been suffering from a type of serving inability clearly of the same kind as that described by *Böhler et al.* All these observations seemed to make worth while a more comprehensive study of the lumbosacral region in cattle, on the one hand as a systematic study on a non-selected slaughter-house material, on the other as a special investigation on bulls suffering from serving disability. In this paper an account will be given of the first of these studies.

Thus the author's purpose has been to study, in a non-selected material of slaughtered animals belonging to different age groups, the pathology of the discs in that region of the vertebral column, in which we know from experience that disc degeneration may appear, viz. the lumbar region and lumbo-sacrum. Furthermore the author has tried to correlate the changes observed with different forms of clinical hind quarter insufficiencies.

MATERIAL AND METHODS

The material includes 200 females belonging to the breed of Swedish red-and-white cattle, killed in the abattoir at Uppsala or—in a few cases—subjected to a post-mortem examination at our department. The age group distribution is shown in the first column of Table 2.

After the animal has been killed the vertebral column is cleft along the *median plane* by means of a machine-saw. The discs and the bodies of the vertebrae were inspected from this cut surface, and also the spinal canal after removal of the spinal cord. By means of a paramedian saw cut through the lumbosacral region a flat piece one centimetre thick was then extracted for radiological and histological examination. This piece contained the caudal half of the body of the last lumbar vertebra, the cranial part of the *os sacrum* and the interjacent disc tissue. Unfortunately, the economic factors involved do not allow an exhaustive examination of this kind at an abattoir.

In order to arrive at an opinion on the clinical importance of the changes observed, the author sent questionnaires to the owners of animals, asking them if the animal had suffered from "back pain", found it difficult to move its hind quarter or shown lameness in a hind leg. The questionnaires also contained inquiries about the age of the animal and about any infectious diseases that the animal might have had. The answers received have been statistically treated.

RESULTS

Macroscopic observations.

Already in new-born calves the discs show a *nucleus pulposus* (n.p.), that is rather diffusely separated from the *annulus fibrosus* (a.f.). The n.p. is not at all of the limpid and gelatinous type found in dog or pig but is of a more gluey, caramel-like consistency that it will keep—except for those pathological changes that may occur—nearly unchanged during the whole life-time of the animal. It shows a cut surface that is homogeneous, white, moist and strongly protruding, thus of course being quite different from the distinctly lamellar, non-protruding cut surface of the a.f. The degree of protrusion and a little more moistness are the only things to indicate the greater water content in the n.p. in calf than that in adult cattle. An analysis of the water content of the n.p. in different age groups among cattle is shown in Table 1. The analysis has been made on collective samples from lumbar discs in 4 animals in each age group and the numbers mark the losses of weight in the samples when they have been dried in a temperature of 105° Celsius.

TABLE 1

<i>The water content of nucleus pulposus in cattle.</i>	
New-born calves	85.3 %
Heifers	73.9 %
3- 5 years	73.0 %
6- 8 "	67.5 %
9-11 "	66.4 %
12 " or more	62.8 %

In calves and heifers no macroscopical signs of a degeneration in the lumbar discs have been found. Table 2 shows the frequency of animals with macroscopically changed discs in the different age groups.

TABLE 2
Lumbar disc degeneration in cattle.

	Number of examined animals	Macrosc. changed discs in %	Lumbosacral Osteo- chondrosis in %
Calves and heifers	33	0	0
3- 5 years	51	27.5	9.8
6- 8 "	68	66.2	33.8
9-11 "	32	93.7	56.3
12 " or more ...	16	93.7	56.3

Already in the age group 3-5 years a considerable number (27.5 %) of the animals in the material examined show macroscopic signs of degeneration of the lumbar discs. The first sign seems to be a yellowish brown discolouration of a.f. and the dorsal part of n.p. in the first

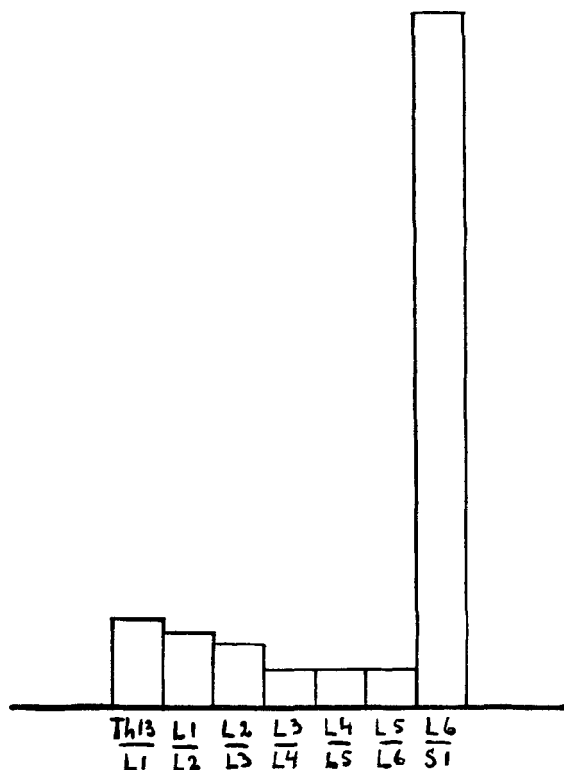


Fig. 1.

The site of lumbar disc degeneration in female cattle.

place and without any disturbances in its continuity. When they do appear, such changes will as a rule be found in most of the lumbar discs, while most of the advanced signs of degeneration have been found in the lumbosacral disc (Fig. 1). Table 2 shows the frequency of lumbar disc degeneration in different age groups, the abovementioned slight changes being included. Severe damage of the type called *osteo-chondrosis* in the table and which has mostly affected the lumbosacral space has been observed occasionally in animals in the 3-5 years age group, in about one third of the animals of the 6-8 years group and in about half of the animals more than 9 years old ($56.3\% \pm 7.1$).

If the term disc degeneration is limited to cases showing definite

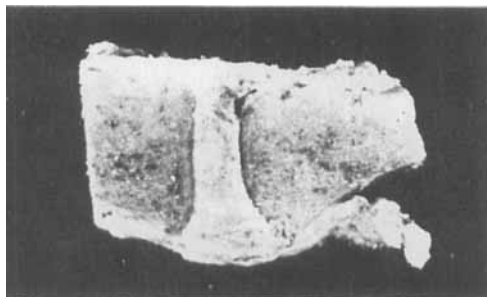


Fig. 2.

Sagittal cut from the lumbosacral space of a 4-year old cow. Brownish discolouration of the dorsal n.p. and a.f., uneven dorso-cranial contour of os sacrum and slight osteosclerosis. Compare radiogram in Fig. 8.

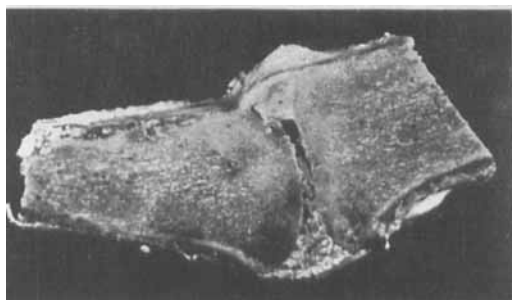


Fig. 3.

Sagittal cut of the lumbosacral space in a 14-year old cow. The disc has shrunk up and shows strong disintegration, especially of the n.p., pronounced osteosclerosis, ruptured annulus near os sacrum and a dorsal protrusion. Compare radiogram in Fig. 20.

ruptures in the disc, as is done by *Friberg* and *Hirsch* (1949), the distribution of disc degeneration within the lumbar spine shows the picture set forth in Fig. 1. The predominating position of the lumbosacral disc in this connection is clearly seen in the figure.

This lumbosacral osteochondrosis shows a very characteristic and consistent pathologic-anatomical picture. Besides the discolouration, which in these cases often will be a brownish green, the picture is characterized by a rupture of the n.p. which is either total or found only in the dorsal half and which is regularly combined with a dorsal rupture of the a.f. (See Fig. 2, 3 and 4). This a.f. rupture practically always is found in the immediate vicinity of the *os sacrum* and reaches different heights dorsally, though it never goes farther than to the *lig. longitudinale int.* In the latter case it may be accompanied by a bulging

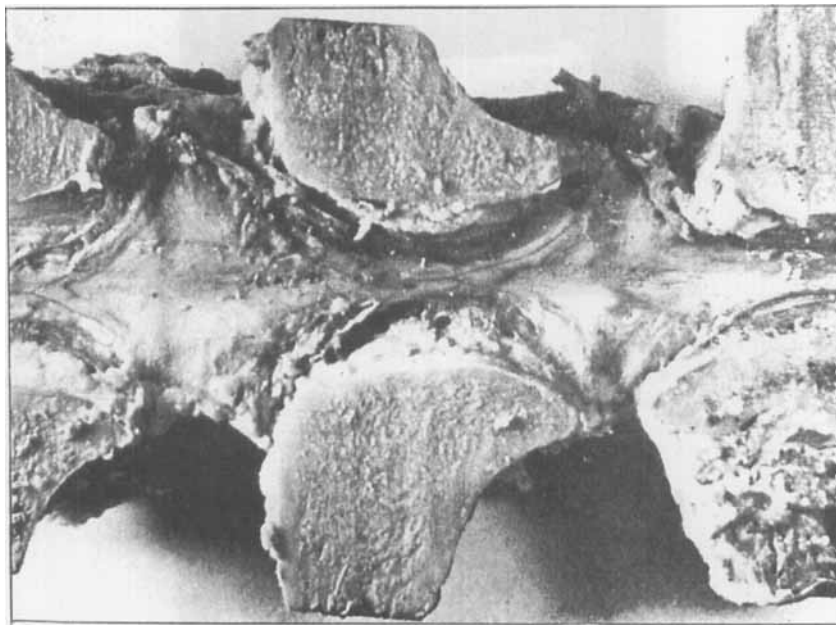


Fig. 4.

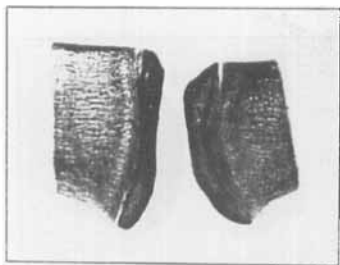
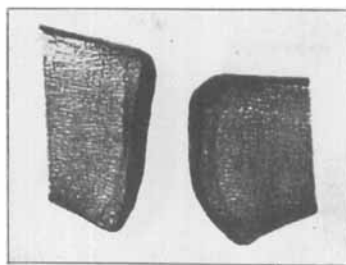
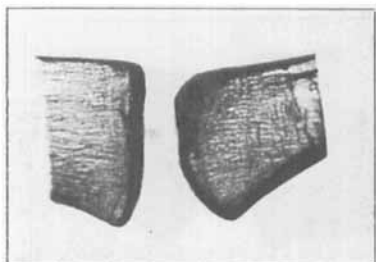
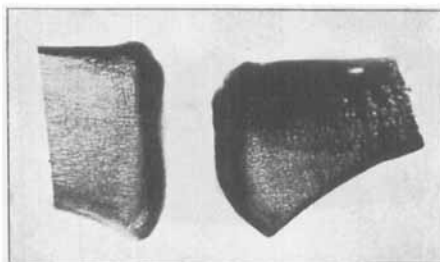
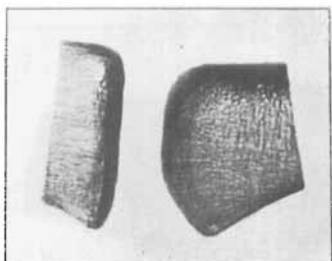
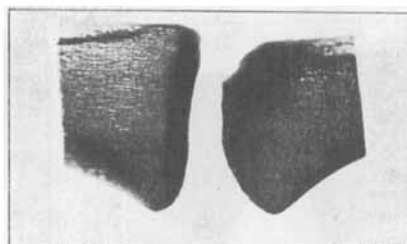
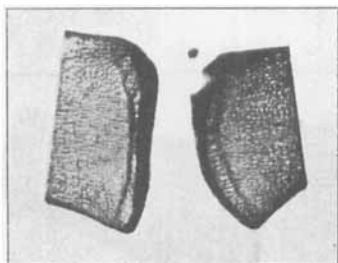
12-year old cow. Dorsal view of a part of the lumbar region with the vertebral arches and the spinal cord taken off. On the disc (LIII/LIV (to the right) there is a small rounded protrusion.

of this ligament—a pseudofluctuating protrusion of varying size. Such protrusions have been observed in 12 cases. They show a tense, semi-fluctuating consistency and a smooth surface and as a rule they are located medially without any other effect than a slight impression in the epidural fat which is found in abundant quantities in cattle. They do not seem to have been able to affect the *cauda equina* in any way whatever.

Dystrophic calcification has been observed only exceptionally (6 cases).

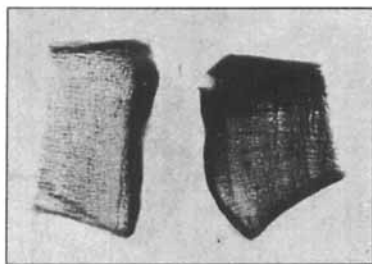
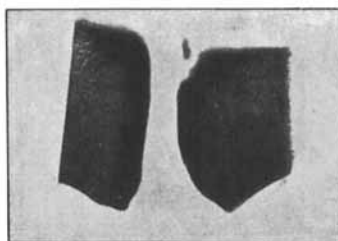
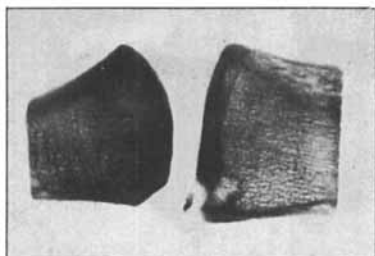
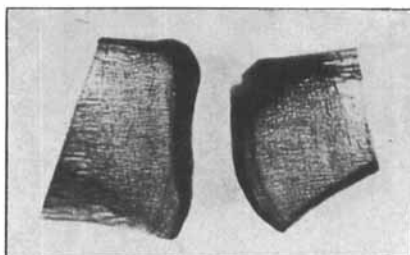
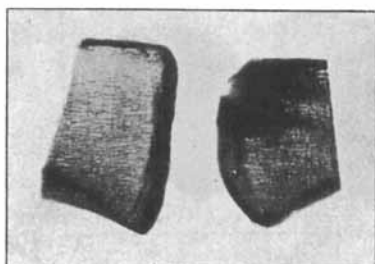
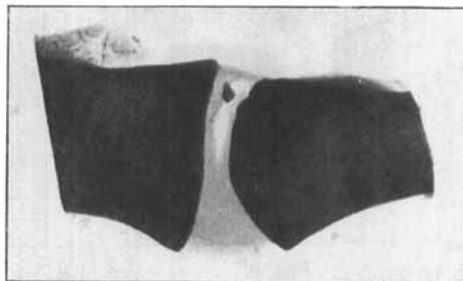
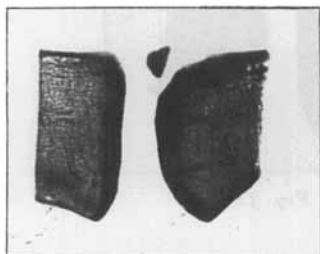
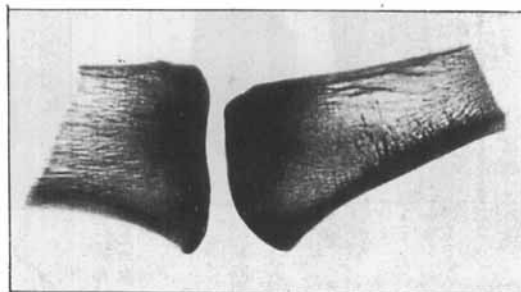
The degenerative decomposition and the rupture of the disc may, in advanced cases, mean a reduction of the lumbosacral space into a narrow slit, filled with a dry detritus and with only the outer lamellae of the a.f. left. Thus there may be a direct osseous contact between the epiphyses of L VI and sacrum, in which case the epiphyses are strongly sclerotized.

Besides the changes in the discs pronounced changes have also been observed in adjacent tissue, especially in the dorsocranial “corner” of the *os sacrum*. They consist of osteolytic processes with a bevelling of this corner or lacunary concavities, often accompanied by a bone

*Fig. 5.**Fig. 6.**Fig. 7.**Fig. 8.**Fig. 9.**Fig. 10.**Fig. 11.**Fig. 12.*

Figs. 5-20.

Radiograms of the lumbosacral space from different animals. Os sacrum is shown to the right in all pictures. Descriptions are given in the text.

*Fig. 13.**Fig. 14.**Fig. 15.**Fig. 16.**Fig. 17.**Fig. 18.**Fig. 19.**Fig. 20.*

fragment disengaged from the sacrum and lying free in the dorsal part of the a.f. Beside this osteolysis there has regularly been found a more or less strongly pronounced sclerosis of the adjacent bone in both sacrum and L VI. More will be said about this phenomenon in the chapter on radiological observations.

Roentgenological observations.

Already the macroscopical observations had shown that the changes in the lumbosacral space did not only include the disc but also the surrounding osseous elements. A radiological study on the centimetre-thick pieces could then be expected to provide further information on the character of this process. The radiographs have been taken without intensifying screens and on a film that was specially suited for the purpose (Ilfex).

Let us first take a look at normal conditions. As distinguished from conditions in man, the bodies of the vertebrae of cattle, as those of all fourlegged animals, have fully developed epiphyses. Thus, in animals we find an "epiphysial plate", not an "epiphysial ring", (see Fig. 5). The epiphysial line coalesces at the age of 3–4 years, and on the present pictures it can be traced as a thin densified line rather high up in the age curve (8–10-year age). Fig. 6 shows a normal lumbosacral space in an 8-year old cow and illustrates the thickness of the compacta and the structure of the spongiosa. As a rule the latter shows trabeculae which are thicker and set more closely together in the *os sacrum* than in the last lumbar vertebra (L VI). Also this phenomenon is a little more pronounced in the dorsocranial "corner" where the compacta is also broader than ventrally.

A more or less pronounced accentuation of this dorsocranial sclerosis is often the only deviation from the normal state that is worth mentioning. It has been observed in many cases without any macroscopical signs of degeneration of the annulus or in cases with relatively slight signs of this kind (see Fig. 7).

As the degree of changes in the discs grows higher it becomes more and more unusual that the changes in the bone are only of a sclerotic nature. Instead, the picture also shows more or less pronounced signs of an osteolytic process, from a certain irregularity in the dorsocranial contour of the *os sacrum* (Fig. 8–10) to extended lacunar "resorptions" or subchondral cysts (Fig. 11–17). These subchondral osteolytic processes sometimes show a very slight sclerosis in their environment (Fig. 11, 12 and 15), and on other occasions they are surrounded by a thick osteo-sclerotic seam (Fig. 13, 16 and 17). In many cases a free bone fragment

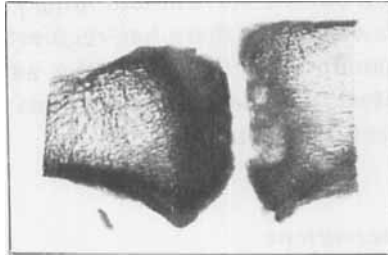


Fig. 21.

Radiogram of the lumbosacral space of a 14-year old cow. Severe osteolytic processes and sclerosis along the bony surroundings of the disc (os sacrum is shown to the left).

has been found in the a.f., corresponding to the concavities in the dorso-sacral contour of the sacrum (Fig. 11–15). These bone fragments as a rule show a roentgenologically rather scarce and porotic structure. Fig. 18 shows how such a bone fragment lies in relation to the annulus rupture near the sacrum which is regularly found in such cases. Fig. 19 and 20, finally, show how the bone fragments in certain cases may correspond to a bevelled and rather sclerotic corner of the sacrum.

In cases with severe changes in the disc and a complete collapse of the space the picture may look like that shown in Fig. 21. In such cases one can see very severe osteolytic and sclerotic processes going on along the epiphysial surfaces of the bodies of the vertebrae and on the ventral side there is a tendency towards osteophytic proliferations.

HISTOLOGICAL OBSERVATIONS

Methods.

The only fixation fluid used is 10 % aqueous solution of formaldehyde. Staining methods: hemalum—eosin, hematoxylin—picric acid fuchsin (van Gieson), Lade-wig's modification of Mallory's anilin blue collagen stain, Scarlet Red, Sudan Black, Hueck's modification of Tiemann-Schmelzers Turnbulls blue method, Lepehne's benzidine test, toluidine blue according to Sylvén, silver nitrate impregnation according to Foot and Foot, and Palmgren's silver staining method. Unstained paraffin sections have been used for the study of fluorescence. Decalcification has been performed according to Perényi.

“Normal” discs (discs showing no macro- and/or microscopical signs of any tissue damage).

In the new-born calf a.f. shows an outer beautifully lamellar and vascularized structure, which gradually becomes more diffuse and rather imperceptibly changes into n.p. The cells of the n.p. are either of the fibrocytic type with an oval or star-formed hyperchromatic nu-

cleus or of a more immature type with a large light-coloured nucleus and a strongly vesicular cytoplasm. The intercellular substance is very loose but nevertheless shows a rather high collagen content. The tissue forms a delicate network of thin decidedly fuchsinophilic fibres. The Foot and Foot test has not shown any definite argyrophilia in this tissue.

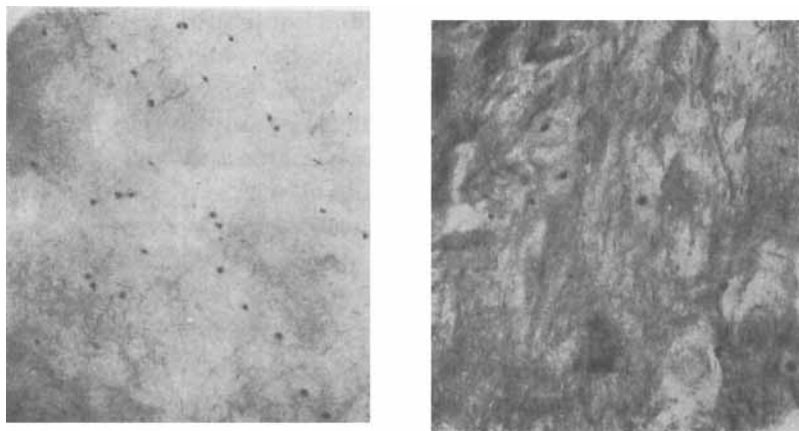


Fig. 22.

N.p. from a new-born calf (A) and from an adult cow (B). Fixed in formaldehyde solution and stained with van Gieson. Magnification: 90 $\times$.

Specimens, impregnated with silver, have also been stained with acid fuchsin, none of the fibres then being left unchanged by the fuchsin. As is the case in dog (*Hansen 1952*) it seems that n.p. does not contain any so-called reticulin fibres that can be found by means of conventional histological methods. *Sylvén et al.* (1951) state that n.p. in children and calves only show a slight fibrousness, that the fibres in question are of so-called reticulin type and that, when the individual grows older they "gradually assume the typical fuchsinophilia of collagen". The amorphous part of the intercellular substance shows a pronounced alcohol resistant metachromasia with toluidine.

When the individual grows older there is a slow increase in collagenization and also a very slow decrease in the amount of "chromotop substance" (Fig. 22). The degree of collagenization in this case is however so small that it does obviously not correspond to the loss of water (Cf. Table 2). Instead it would seem that a certain part of the responsibility for this process lies with the degenerative changes which appear very early in the histological picture. The collagenization as a process of maturation is characterized by certain signs of a cellular

activity, among other things as cell-groups of the same type as those found in growing cartilage.

This picture in principle corresponds to that of the fibroid and chondroid metamorphosis in the n.p. of dog (Hansen 1952). It was stated in that work that the collagenization of the n.p. is a maturation process and not a degeneration. Hirsch *et al.* (1952) express this view as follows: "During aging, this avascular tissue thus increases its amount of protein material and keeps the original content of carbohydrate. In a biological sense this can hardly support the idea of "degeneration" of the nucleus with age". The authors have shown that the collagen content per unit tissue volume in normal human discs increases with advancing age while the polysaccharides remain at nearly the same level. The ratio between the sulphur and collagen contents thus decreases which explains the decrease in the water-binding capacity. Degenerated discs, however, show a considerable decrease in sulphur which means a still stronger decrease in the sulphur-collagen ratio.

Degenerated discs (discs with macro- and/or microscopical signs of any tissue damage).

An early macroscopic change was found in the form of a yellowish-brown discolouration of the a.f. firstly. Its histological counterpart is an infiltration of sudanophilic granules into the intercellular substance that is otherwise unchanged or degenerated. These granules are partly resistant towards alcohol and are autofluorescent with a golden tinge, and thus it may be assumed that at least partly they consist of lipofuscin.

In cases with advanced processes of disintegration with ruptures in the a.f. the macroscopical examination showed a discolouration of a more brownish green tinge. The histological basis for this discolouration is partly a benzidine-positive substance, partly hemosiderin—the latter in macrophages of granulation tissue emanating from the epidural space and the spongiosa.

At the same time as the sudanophilic infiltrations both a.f. and n.p. show signs of degeneration in the form of small foci of granular disintegration of the intercellular substance or large foci with picrinophilic fragments. The picture is in principle the same as that found in dog, but differs in one respect: Calcification is very rarely found in cattle.

The histological picture of the very characteristic annulus ruptures near the sacrum is best studied on sagittal sections.

The a.f. rupture as a rule has taken place in the immediate vicinity of the attachment of the lamellae on the cartilage plate (c.p.) and extends as far as the outmost lamellae, sometimes making them bulge and thus causing a protrusion. It is filled out with a jumble of lamellae



Fig. 23.

Part of the dorso-cranial "corner" of *os sacrum* to the right and disc tissue to the left. The picture shows a cross fracture of a subchondral bone trabecula. The defect is filled up with connective tissue, rich in collagen and vessels. The bone fragment, being the result of this avulsion fracture, is too far dislocated to be visualized in the same field of sight. van Gieson. Magnification: 90 $\times$.

that have been "ground to pieces" and necrotic tissue from n.p. and a.f. Pronounced changes in the disc are regularly accompanied by changes in the dorsocranial "corner" of the sacrum. As a rule this area is more or less strongly sclerotized with very narrow medullary cavities and Haversian canals. C.p. can be rather intact or show local defects. In all cases where a free bone fragment has been observed in the a.f. a corresponding defect in the dorsocranial "corner" of the sacrum has been found both histologically and roentgenologically. The contour is then characterized by a lacunary concavity, which is not covered by the c.p. and which is more or less completely filled with connective tissue rich in collagen and strongly vascularized. The borders of the defect show fractured bone trabeculae (Fig. 23) and signs of osteolysis without any osteoclasts. From this defect a vascularization of the disc has taken place. The bone fragment will be found in the a.f. more or less dislocated and with a strongly vascularized connective tissue along the border of the fracture. Its cranial surface is covered with the corresponding part of the c.p., on

which the outer lamellae of a.f. are fixed, the latter as a rule being rather intact. The bone fragments often show signs of an osteolysis with regressive nuclear changes in the osteocytes and a replacement of the bone lamellae with a connective tissue rich in collagen.

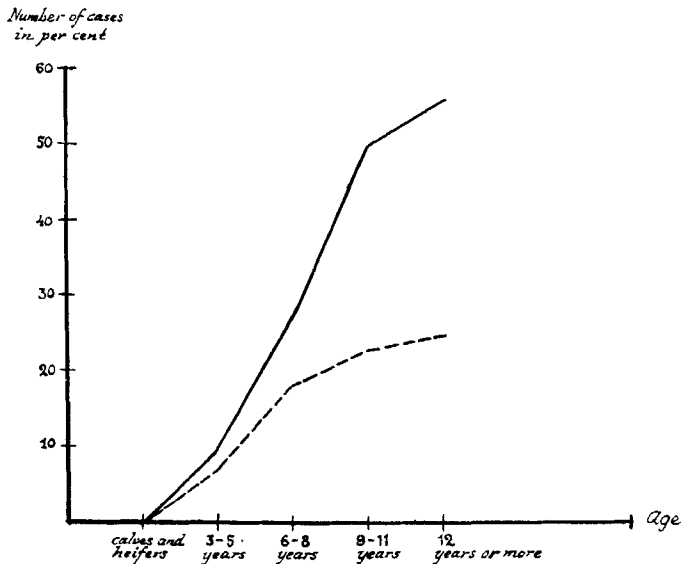


Fig. 24.

Frequency curves for lumbosacral osteochondrosis (unbroken) and clinical signs of back trouble' (dotted).

Sometimes it is also possible to observe, in connection with regressive changes in the c.p., subchondral bone cysts of the same type as in *arthrosis deformans*. They show signs of osteolysis (still without osteoclasia), which is sometimes complete. The defect is filled out with a connective tissue rich in collagen and relatively strongly vascularized.

Changes in the c.p. and bone have not been observed in this material without a disc degeneration at the same time, while a disc degeneration need not be accompanied by the above changes.

The clinical significance of the lumbosacral disc lesion.

The present disc study has been performed on an abattoir material and the economical factors involved have prohibited every other kind of pathologic-anatomical examination. Also the animals have not been examined clinically. The only possibility of getting an idea about the clinical importance of the observed lesions has thus consisted in

sending questionnaires to the owners of the animals. It is a matter of course that an investigation of this kind can only give a rather limited result. However, a short account of the outcome of this investigation will be given.

Answers were received from about 90 % of the owners. In Fig. 24 we can see what the frequency curve for objectively observable clinical hind quarter troubles looks like. In the advanced age group 25 per cent of the animals were reported to suffer from some kind of trouble. The frequency curve for the observed lumbosacral changes is steeper and reaches 56 per cent in the last age group. The figure thus shows that a considerable number of the cases with observable lumbosacral changes must run their course without any objectively observable clinical symptoms, and it does not provide any information on to what extent these cases are responsible for clinical troubles. As has already been said, no information is available on the frequency of other morphological changes in the hind quarters, e.g. arthroses in the hind legs. Table 3, on the other hand, shows a statistical probability of a higher frequency of hind quarter troubles in the group that shows severe changes in the lumbosacral space, compared to a group of animals of the same average age showing no such changes.

The prolapse of LIII/LIV described in Fig. 4 was observed in a 12-year old cow, subjected to a post-mortem because of its sudden death caused by a traumatic pericarditis and which, during the last years of its life, had difficulty in moving its hind legs. This cow was subjected to a complete post-mortem, but no other morphological changes that might have explained the clinical troubles were found.

In this connection also those cases of serving disability in bull which were mentioned in the introduction are worth noting.

The above indicates that *in certain cases the observed lumbar and*

TABLE 3
Frequency of clinical symptoms in lumbosacral osteochondrosis.

	Animals with some trouble in the back and/or hind quarter	Animals without such troubles
Animals with severe lesions of the lumbosacral space ¹ ...	13	31
Animals without such lesions	5	43
$\chi^2 = 5.12^* \text{ (d.f. = 1)}$		

¹ These two groups of animals are comparable concerning age, the average age being 8.6 years in each one.

especially the lumbosacral changes in discs and bodies of vertebrae can result in clinical troubles, though most cases run their course without any objectively observable clinical symptoms.

However, the present investigations have not indicated in which way the lumbosacral osteochondrosis would result in clinical symptoms. In those cases which showed a protrusion, the abundant epidural fat in cattle has, as has already been said, prevented its pressing on the *cauda equina*. In a small number of cases which, in spite of the method used by the butcher, have allowed the extrication of samples from spinal cord or nerve roots for histological examination, no certain changes have been found. In this connection it should perhaps be recalled that the pain accompanying a discogenous lumbago in man has not yet been satisfactorily explained. Besides a compression and degeneration of the nerve roots as shown e.g. by *Lindblom* and *Rexed* (1948) histologically in lateral disc prolapses, the possibility of an irritation of nerve tissue in the ligament system surrounding the disc has been discussed, among others by *Wiberg* (1949).

At last there may be some reason for asking oneself whether the lumbosacral osteochondrosis could be the morphological basis of any well-defined, but etiologically unknown clinical entity. Then one must mention for instance the spastic syndrome, described for the first time by *Suter* (1934) as "Krämpfigkeit des Rindes". According to *Roberts* (1953) the disease appears in middle-aged and older animals and has no verified morphological basis. *Roberts* mentions that he has not been able to establish any signs of spondylitis at post mortem. He suspects the disease to be located to the central nervous system and to be of a hereditary nature. There are grounds, I think, for making a closer study of the lumbosacral joint when this disease is concerned.

DISCUSSION

It is well known that the relatively important types of disc degeneration in man and dog are mostly found in those portions of the vertebral column which are subjected to the strongest mechanical stress. At least as far as dog is concerned it has also been shown that severe disc injuries of this kind (especially dorsal protrusions) are preceded by systemic changes in what might summarily be called "the disc organ" (*Hansen* 1952). The portion most subjected to stress in man is the low back region and in dog the thoracolumbar transition.

In cattle the present investigation has shown that the lumbosacral disc is the one that has definitely been most often subjected to changes and the one in which the changes have been the most pronounced. This tallies completely with what is known about man and dog. Because of the total lack in cattle of so-called anticlinia (*Slijper* 1947) with backwards-sloping *procc. spinosi* in all vertebrae and with *m. multifidus*

dorsi as the most important back muscle, practically all bending and straightening of the vertebral column takes place in the lumbosacral space. The movement in other discs is of a very limited nature.

A severe lumbosacral osteochondrosis is built up by changes in all tissue in the space and with an indubitable priority for the changes in the disc. The latter of course mean a reduction in the functional ability of the disc with abnormal stresses on the c.p. and adjacent bones, above all the dorsocranial "corner" of the sacrum. In slight cases this results in an accentuation of the sclerosis which is already normally found in this portion of the bone. When the changes are of a more serious nature, among other things showing the characteristic rupture near the sacrum, both c.p. and sacrum have been subjected to greater stress, resulting in a number of slight injuries to the c.p. and bone and in advanced cases a portion of the bone has been torn off. *The idea that the free bone fragments found in the a.f. are the result of an avulsion fracture is, in the author's opinion, strongly supported by the morphological picture.*

In man *Schmorl* called attention to formations which possess many morphological similarities to the above processes in cattle which I have interpreted as being avulsion fractures. In an elderly woman *Schmorl* observed an avulsion fracture on the ventro-cranial corner of a lumbar vertebra. In 1930 *Janker* described these changes as "persistierende Wirbelkörperepiphysen", a theory that must certainly have very few advocates to-day. Also, in 1932 *Schmorl* refutes this theory and says "es lässt sich einwandfrei nachweisen, dass die Abtrennung dadurch erfolgt, dass die Bandscheibengewebe in die Spongiosa verlagert wird". A pre-requisite for these intraspongious prolapses would then be, that n.p. is intact and has conserved its turgor, *Schmorl* continues, thus altering his earlier opinion. *Schmorl's* new outlook has won many adherents (*Schulze* 1937, *Junghanns* 1939, *Meyenburg* 1946, *Begg* 1954, et al). In 1933 *Niedner* describes "Schaltknochen in den Zwischenwirbelscheiben" as bone tissue formed in this place, the reason for this process being that degenerative changes in the a.f. result in ingrowth of vascular and osteogenic tissue. *Brocher* (1944) regards these separated pieces of bodies of vertebrae as the result of an extension fracture and thus counts himself among the very small number of adherents to *Schmorl's* former opinion. *Meyenburg* (1946) described the first case of posterior localization of a separated piece of a body of a vertebra. *Reimers* (1951) examined "sequestered pieces" removed from discs during operations, and in more than half of the cases these pieces were observed to contain parts of c.p. with adhering osseous matter. For this reason he considered the cause of these disc prolapses to be a chondrosis dissecans in the c.p. *Begg* (1954) described these processes, which are in man most often located anteriorly, as "herniation of the nucleus pulposus beneath the epiphysial ring". *Lamb* (1954) observed this process in children.

In cattle, it is not only the morphological picture that points to an avulsion fracture, but there are also several factors which go strongly against the other hypotheses mentioned in the above. The epiphyses of

the bodies of the vertebrae of the quadrupeds exclude the possibility of "persistierende Wirbelkörperpiphysen". Also, intraspongious prolapses are rare among animals as a whole. Only one case in dog has been described (*Hansen 1952*). Nor have the microscopic injuries to the c.p. observed in the present material in any case been accompanied by an intrusion of disc material into the sacrum. Finally, *Niedner's* theory of ossification through ingrown osteogenic tissue might in this connection perhaps have explained an osseous deposit on the front surface of the sacrum but hardly the existence of free bone fragments.

Lindemann and *Kuhlendahl* (1954) regard the disease of disc degeneration as a process going on exclusively in the disc without any participation from c.p. and adjacent bone. *Osteochondrosis vertebrae* is their term for primary changes in the c.p. with secondary processes in both disc and bone, which means that they think of this process as analogous to that involved in *arthrosis deformans*.

In spite of this definition I have used the term osteochondrosis for this process in cattle. *Hildebrand* (1933) and *Junge* (1950) have used this term before in order to designate phenomena of a similar character, when they considered that the injury in the c.p. was secondary to a disc degeneration. The more one studies the pathology of the discs, the more one becomes inclined to regard all disturbances in the intervertebral spaces as primary disc degeneration. However, there remains much to do before this assertion is proved. Till then, however, it seems in any case pardonable to use the term osteochondrosis in connection with these processes. The intimate connection between a.f. and c.p. makes the latter differ from ordinary joint cartilage, and for that reason it is not necessary to limit oneself to the c.p. in order to find analogies to arthroses.

Sylvén et al. (1951), *Paulsson et al.* (1951), *Malmgren* and *Sylvén* (1952) and *Hirsch et al.* (1952) have used calf discs for certain investigations of a basic research character. When comparative disc research is concerned it may be worth while to call attention once more to the fact that the n.p. of calf differs from that in dog and pig, the n.p. in calf containing less water than the others. The water content of the n.p. in 6-month old pigs is ca. 89 % and in cattle of the corresponding age (state of development) about 74 %. As far as I have been able to ascertain there is on the other hand a close resemblance between man and cattle—in this particular respect. *Püschel* (1930) and *Keyes* and *Compere* (1932) state that the water content in the n.p. of new-born children is 88 %. The above facts seem to make the bovine disc a very suitable object for disc studies with a view to obtaining a clear conception of the disc syndrome, one of the scourges of mankind.

SUMMARY

Systematic studies on discs in cattle have been lacking in the literature until now. The author gives an account of the discs of the lumbar region in 200 female cattle with special attention paid to the lumbosacral space. The following results were obtained:

1) The discs in calf show an n.p. of a gluey, caramel-like consistency, rather diffusely separated from the a.f. In this respect the calf differs from dog and swine, the n.p. of which is limpid and gelatinous. Histologically, the n.p. is collagenized already from the beginning, the collagen content of course increasing with the age of the animal.

2) The water content of n.p. decreases from ca. 85 % in newborn calves to 63 % in old cows (Table 1).

3) Signs of degeneration in the discs appear very early, as can be seen from Table 2. The process is accompanied by a brownish, sometimes greenish discolouration, due partly to lipofuscin, partly to hemoglobinogenic pigments.

4) The lumbosacral space is most often and to the greatest extent subject to changes (Fig. 1). In the author's opinion this is due to the fact that this region in cattle is the one most subjected to mechanical stress.

5) The changes in the lumbosacral space include not only the disc but also the c.p. and adjacent bone. For that reason this process has been called osteochondrosis, in accordance with *Hildebrand, Junge* and others. Through a primary disc degeneration the a.f. develops a dorsal rupture as a rule near the sacrum and sometimes a protrusion towards the spinal canal takes place. C.p. and the dorsocranial "corner" of the sacrum receive secondary injuries. The bone changes are sclerosis, osteolytic processes with the creation of subchondral bone cysts and in many cases an avulsion fracture of parts of this "corner" (Figs. 5-21). The author discusses the pathogenesis of this process with respect to similar changes in man.

6) Finally the author gives an account of factors indicating that the lumbosacral osteochondrosis in cattle may in some cases result in clinical symptoms, though most cases never show any objectively observable clinical symptoms.

RESUME

Des études systématiques des disques chez le bétail bovin ont manqué jusqu'ici dans la littérature. L'auteur passe en revue les disques de la région lombaire chez 200 femelles en portant tout particulièrement son attention sur l'intervalle lombo-sacré. Les résultats suivants ont été enregistrés:

1) Dans les disques des veaux le nucleus pulposus est d'une consistance gluante, ressemblant au caramel; il est assez diffusément séparé de l'annulus fibrosus. A cet égard, le veau diffère du chien et du porc chez lesquels le nucleus pulposus est limpide et gélatineux. Au point de vue histologique, le nucleus pulposus est collagénisé déjà au début, la teneur en collagène augmentant évidemment avec l'âge de l'animal.

2) La teneur en eau du nucleus pulposus tombe d'environ 85 % chez les veaux nouveaux-nés à 63 % chez les vieilles vaches (tableau 1).

3) Des signes de dégénération des disques apparaissent très précocement comme on peut le voir au tableau 2. Le processus est accompagné d'une décoloration brunâtre, quelquefois verdâtre, due en partie à la lipofuchsine, en partie aux pigments hémoglominogéniques.

4) L'intervalle lombo-sacré est le plus souvent et dans la plus grande extension le siège de modifications (fig. 1). De l'avis de l'auteur, cela est dû au fait que chez les bovins cette région est celle qui doit supporter les plus gros efforts mécaniques.

5) Les modifications dans l'intervalle lombo-sacré ne portent pas seulement sur le disque, mais aussi sur le cartilage plat et l'os adjacent. C'est pour cette raison que ce processus a été appelé ostéochondrose, d'après *Hildebrand, Junge* et d'autres.

En raison de la dégénération du disque, l'annulus fibrosus donne lieu à une rupture dorsale, en général près du sacrum, avec parfois une protrusion vers le canal rachidien. Le cartilage plat et l'«angle» dorso-cranien du sacrum sont le siège de lésions secondaires. Les modifications osseuses telles que la sclérose, les processus ostéolytique avec formation de kystes osseux subchondraux et dans beaucoup de cas une avulsion de cet «angle» (fig. 5-21) en sont le résultat. L'auteur discute de la pathogénèse de ce processus en relation avec les altérations similaires chez l'homme.

6) Enfin, l'auteur donne un aperçu des facteurs qui indiquent que l'ostéochondrose lombo-sacrée chez les bovins peut dans certains cas provoquer des symptômes cliniques, bien que dans la plupart des cas il ne soit pas possible d'observer des symptômes cliniques objectifs.

ZUSAMMENFASSUNG

Systematische Untersuchungen der Zwischenwirbelscheiben des Rindes haben bis jetzt in der Litteratur gefehlt. Der Verfasser berichtet über die Scheiben der Lendengegend von 200 weiblichen Rindern unter besonderer Berücksichtigung des lumbosakral Raumes. Folgende Ergebnisse wurden erhalten:

1) Die Scheiben beim Kalb zeigen einen nucleus pulposus von klebriger, karamelartiger Konsistenz, ziemlich weitgehend vom annulus fibrosus getrennt. In dieser Hinsicht unterscheidet sich das Kalb vom Hunde oder Schwein, deren n.p. durchsichtig und gelatineartig ist. Histologisch zeigt der n.p. schon im Beginn Kollagen und der Kollagengehalt nimmt natürlich mit dem Alter des Tieres zu.

2) Der Wassergehalt des n.p. nimmt von ca. 85 % bei neugeborenen Kälbern zu 63 % bei alten Kühen ab (Tabelle 1).

3) Wie aus Tabelle 2 ersehen werden kann treten Zeichen von Degeneration sehr zeitig auf. Dieser Vorgang wird von einer bräunlichen, manchmal grünlichen Verfärbung begleitet, die teilweise durch Lipofuszin, teilweise durch Hämoglobin-Abkömmlinge bedingt ist.

4) Der lumbosakral Raum ist am häufigsten und am ausgeprägtesten Veränderungen unterworfen (Abb. 1). Nach der Meinung des Verfassers ist diese Region beim Rind die am stärksten mechanisch beanspruchte.

5) Die Veränderungen im lumbosakralen Raum betreffen nicht nur die Zwischenwirbelscheibe sondern auch c.p. und anschliessenden Knochen. Aus diesem Grunde wurde dieser Prozess in Übereinstimmung mit *Hildebrand*, *Junge* und anderen als Osteochondrose bezeichnet. Infolge einer primären Scheibentegeneration entwickelt sich im a.f. eine dorsale Ruptur meistens in der Nähe des Sacrum und manchmal findet eine Vorbuchtung gegen den Rückenmarkskanal statt. C.p. und die dorso-craniale "Kante" des Sacrum werden sekundären Schäden ausgesetzt. Die Knochenveränderungen sind Sklerose, osteolytische Vorgänge mit Entstehung von subchondralen Knochenzysten und in vielen Fällen Abrissbrüche von Teilen dieser "Kante" (Abb. 5–21). Der Verfasser bespricht die Pathogenese dieses Prozesses unter Rücksichtnahme auf ähnliche Veränderungen beim Menschen.

6) Zum Schluss gibt der Verfasser eine Übersicht der Faktoren, die darauf hinweisen, dass die lumbale Osteochondrose beim Rinde in einzelnen Fällen zu Symptomen führen kann, obwohl die meisten Fälle niemals objektive klinische Symptome aufweisen.

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