

From the Department of Pathology and the Department of Surgery,
Veterinary College of Norway, Oslo.

OSTEOCHONDROSIS AND ARTHROSIS IN PIGS

IV. EFFECT OF OVERLOADING ON THE DISTAL EPIPHYSEAL PLATE OF THE ULNA

By

Trygve Grøndalen and Jorunn Grøndalen

GRØNDALEN, TRYGVE and JORUNN GRØNDALEN: *Osteochondrosis and arthrosis in pigs. IV. Effect of overloading on the distal epiphyseal plate of the ulna.* Acta vet. scand. 1974, 15, 53—60. — The effect of overloading on the distal epiphyseal plate of the ulna is described. The right forelegs of 6 pigs were fixed such that the pigs were forced to walk on 3 legs during 2 periods, the first of 12 days duration at about 50 kg live weight, and the second of 7 days at about 100 kg live weight. Osteochondrosis developed to a more marked degree in the left than in the right epiphyseal plate of the ulna, but this did not lead to reduced lengthwise growth of the bones to any great extent. The overloading led to reversible changes in the distal epiphyseal plate of the ulna. It is conceivable that this was due to disturbances in the metaphyseal blood flow. It is also conceivable that the overloading was neither great enough nor of sufficient duration to affect the epiphyseal blood flow with consequential irreversible damage to, and premature closure of, the epiphyseal plate.

osteochondrosis; overloading; epiphyseal plate growth; pig.

Osteochondrosis in the distal epiphyseal plate of the ulna in pigs is widespread in Norway as well as in other countries. The incidence in Norwegian slaughter pigs is 60—70 % (*Grøndalen* 1974). Lesions of the osteochondrosis type have been induced in the distal epiphyseal plate of the ulna by overloading the forelegs. This has been described from England by *Walker et al.* (1966) and from Finland by *Paatsama et al.* (1972). In Norway it is not unusual to see pigs which have so-called x-legged forelegs. This is a condition where the axis of the forelimbs “break off” so that the lower part of the leg from the carpus

downwards points outwards (abducted). In order to see if this could have any connection with reduced lengthwise growth of the ulna due to osteochondrosis in the distal epiphyseal plate, a loading trial was carried out on pigs during the period 1971—72.

MATERIALS AND METHODS

The material consisted of 6 pigs. They were fed at average levels on a commercial pig-ration, and were kept in the same cement-floored pen. When the animals reached 45—55 kg live weight, they were anaesthetized with i. v. sodium thiopentone, and radiographic examination of all the distal radii and ulnae was carried out. Thereafter, the right foreleg was fixed in a flexed position by means of an elastic plaster bandage. This was kept on for 12 days. The animals were thus forced to walk on 3 legs, the left foreleg being subjected to overloading. When the bandage was removed, the animals were again anaesthetized and radiographically examined as before.

Radiographic examination and fixation were repeated 3 months later, at about 90—100 kg live weight. The bandage was kept on for 7 days. Radiographic examination was not carried out at the end of this period.

The animals were examined clinically and post mortem with regard to x-legged forelegs, and whether or not there were any differences between right and left foreleg. They were slaughtered at the age of 12—13 months. The distal parts of the radius and ulna were radiographically examined also post mortem. The animals were gross examined for evidence of osteochondrosis in the distal epiphyseal plate of the radius and ulna, and for evidence of osteochondrosis and arthrosis in the elbow and stifle joints.

The length of the radius and the distal part of the ulna were measured in mm from the proximal joint surface of the radius to the distal joint surface of the radius and the ulna respectively (Fig. 1).

Sections for histological examination were taken from the distal epiphyseal plates of the ulna. The sections were treated as described in a previous article (Grøndalen 1974). By the radiographical and patho-anatomical examinations, the epiphyseal plates and metaphyses were judged as being normal (—) or changed (+ or ++) (Table 1).

Table 1. Results from the investigation of ulna.

Pig no.	Side	Radiographical investigation of the distal epiphyseal plate and the metaphysis of ulna				Gross post-mortem investigation of the distal epiphyseal plate and the metaphysis of ulna	Histological investigation of the distal		The length of radius and the distal part of ulna, and the difference between them (in mm)		
		before the first over-loading	at the first over-loading	before the second over-loading	post mortem		epiphyseal plate of ulna	metaphysis of ulna	radius	distal part of ulna	difference
73	right	—	—	—	—	—	—	154	144	10	
	left	—	++	—	—	—	+	154	144	10	
81	right	—	—	—	—	—	—	152	144	8	
	left	—	++	—	—	—	—	151	142	9	
101	right	—	—	—	—	—	—	157	149	8	
	left	—	++	—	—	+	+	157	148	9	
106	right	—	—	—	—	—	—	153	144	9	
	left	—	++	+	—	—	—	152	143	9	
112	right	—	—	+	—	—	—	157	148	9	
	left	—	++	+	—	+	++	157	146	11	
113	right	—	—	+	—	—	—	156	148	8	
	left	—	++	—	—	+	++	155	146	9	

RESULTS

The results of the examination of the ulna are shown in Table 1.

Clinical examination

The animals showed no sign of lameness before fixation of the right foreleg, but had somewhat of a problem in walking on 4 legs after ended fixation. Right foreleg lameness persisted in 2 of the pigs for 2—3 weeks.

During the second period of fixation, the animals had trouble in walking on 3 legs and spent a lot of time lying down. All animals became slightly x-legged, but clinically there were no signs of any differences between right and left foreleg.

Radiographical examination

The distal epiphyseal plates of the radius and ulna appeared normal prior to the first fixation of the right foreleg. At the end of the first period of fixation, the distal epiphyseal plate of the

left ulna appeared greatly thickened with an uneven junction to the metaphysis in all 6 pigs (Fig. 2). The distal epiphyseal plate of the right ulna and the distal epiphyseal plate of the radius still appeared normal (Fig. 3). On examination 3 months later immediately prior to the second period of fixation of the right foreleg, the obvious differences between the distal epiphyseal plates of the right and left ulna had disappeared, although some abnormalities were observed. One animal showed radiographic changes in the form of less dense areas towards the metaphysis in the distal epiphyseal plates of both ulnae, while 1 animal showed such changes in the distal epiphyseal plate of the right and 1 of the left ulna. Three of the animals appeared to be normal or had very slight and indistinct changes. Post-mortem radiographical examination did not demonstrate any distinct changes in the right or the left epiphyseal plates.

Gross examination

Bilateral osteochondrosis in the medial condyles of the femur was demonstrated on patho-anatomical gross examination in 5 pigs and arthrosis in the medial condyles of the femur in 1. Bilateral arthrosis in the elbow joint was present in 3 pigs. Gross demonstrable thickened areas in the distal epiphyseal plate of the left ulna and/or cartilage islets in the metaphysis were present in 3 pigs. All the right, and 3 of the left ulnar epiphyseal plates seemed grossly normal, in spite of having in places a very wavy contour.

Measurement of the length of the radius and of the distance between the proximal joint surface of the radius and distal joint surface of the ulna, showed very small differences between the right and the left side (Table 1). The left radius was 1 mm shorter than the right radius in 3 animals, and the same length in 3. The left ulna was 2 mm shorter than the right ulna in 3 animals, 1 mm shorter in 2 and the same length in 1 animal. The difference between radius and ulna in the left leg was 2 mm greater than in the right leg in 1 case, 1 mm greater in 3 cases and the same in 2 cases.

Histological examination

On histological examination, the contours of the ulnar epiphyseal plates were markedly wavy, and eosinophilic streaks

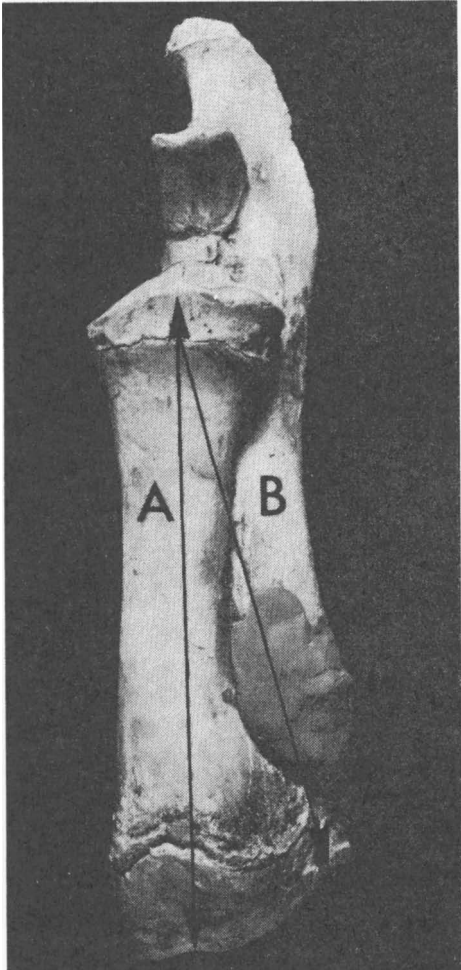


Figure 1. Arrows showing lengths measured on radius (A) and ulna (B).

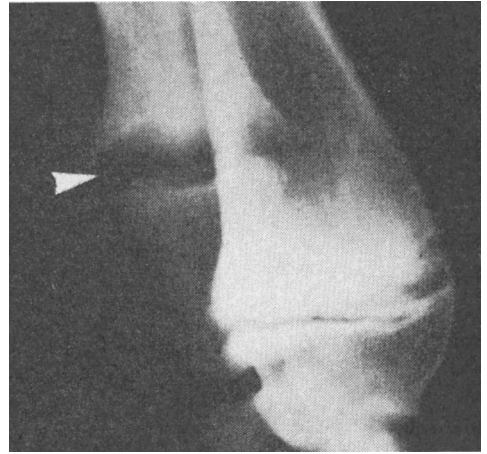


Figure 2. Radiograph showing thickened distal epiphyseal plate of left ulna (arrow) at the termination of overloading. Pig no. 101, 50 kg.

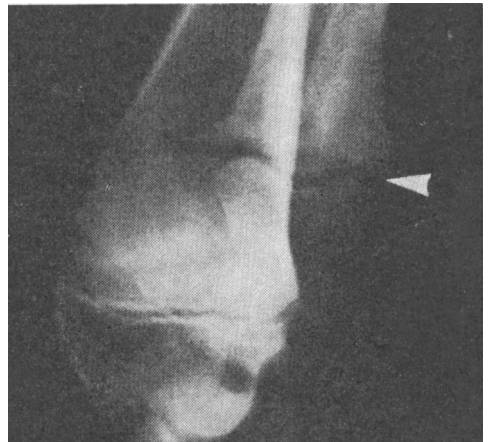


Figure 3. Radiograph showing normal distal epiphyseal plate of right ulna (arrow) at the termination of fixation, same pig as Fig. 2.

were present in the plates. This was especially true in the case of the left epiphyseal plates. These findings are not included in Table 1. In 2 cases (pigs nos. 73 and 101) the left ulna showed connective tissue proliferation in the epiphyseal side of the epiphyseal plate. There were considerable local abnormalities in the vascularization of the cartilage columns and in the columnar structure in the left ulnar epiphyseal plate in 2 cases (nos. 112 and 113). The left ulnar metaphysis in 3 pigs (nos. 101, 112 and 113) showed small cartilage islets, in 1 case about 1.5 cm from the epiphyseal plate.

DISCUSSION AND CONCLUSIONS

Measurements of the difference in length between the radius and ulna, seen together with clinical investigations, have shown that there are great differences in the length of ulna and radius in pigs which are markedly x-legged (*Grøndalen*, unpublished). X-legged pigs are seen relatively often in Norway, though seldom of an extreme degree. The purpose of the trial involving the fixation of the right foreleg was to see if severe osteochondrosis (*Grøndalen* 1974) in the distal epiphyseal plate of the ulna caused a premature closure of the epiphyseal plate, reduced lengthwise growth and marked x-leggedness, something which is seen in dogs in which the distal epiphyseal plate of the ulna is injured (*O'Brien et al.* 1971). *O'Brien et al.* have shown a changing of the axis angle, with abduction distally, in the injured leg 5—7 weeks after the injury occurred in dogs which are injured when about 4 months old. That overloading brings about the development of osteochondrosis type lesions in the distal epiphyseal plate of the ulna in pigs has been demonstrated by *Walker et al.* (1966) and *Paatsama et al.* (1972). The present investigation was based on the use of the left foreleg of the pig as the trial object and the right foreleg as a control. Length measurements showed up a tendency to decreased lengthwise growth in the overloaded bone. This tendency was so slight that the results, though with reservations concerning overloading over a longer period of time, can be said to support the suppositions of *Vaughan* (1971) that the most common lesions in the distal epiphyseal plate of the ulna do not lead to x-leggedness to any appreciable degree in pigs. The material of *O'Brien et al.* seems to support the view that it is unlikely that the ani-

mals were slaughtered too soon and that changes would have developed later on.

Trueta & Trias (1961) showed that pressure of limited duration on an epiphyseal plate leads to high columnar cartilage. This, however, and vascularization of the columns become normal again after a while if the pressure is removed before damage to the epiphyseal side of the epiphyseal plate has occurred. If damage to the epiphyseal side does happen, there will be a premature closure of the epiphyseal plate. Interference in epiphyseal blood flow leads, according to *Trueta & Amato* (1960), to irreparable damage and premature closure of the epiphyseal plate, while interference in metaphyseal blood flow leads to reduced calcification and high columnar cartilage. Compression trials carried out by *Trueta & Trias* showed that the epiphyseal blood supply is much better protected against excessive pressure than the metaphyseal blood flow. Radiographic examinations in the present study showed that the epiphyseal plate apparently had become thickened after overloading (Fig. 2) and that the condition was reversible. Histological examination showed that vascularization of the columns and the cartilage columnar structure at slaughter were mostly intact and that patho-anatomical changes were relatively slight. This suggests, with the support of the findings of *Trueta & Amato* and *Trueta & Trias*, that the load on the ulna was not so great that significant damage was caused to the epiphyseal side of the epiphyseal plate, with consequent premature closure and reduced lengthwise growth, but that the metaphyseal blood supply was affected. The experimentally produced and naturally occurring lesions seemed to be similar, so that the conclusions above should also apply as regards the spontaneously occurring lesions in the distal epiphyseal plate of the ulna.

REFERENCES

- Grøndalen, T.*: Osteochondrosis and arthrosis in pigs. I. Incidence in animals up to 120 kg live weight. *Acta vet. scand.* 1974, 15, 1—25.
- O'Brien, T. R., J. P. Morgan & P. F. Suter*: Epiphyseal plate injury in the dog: A radiographic study of growth disturbance in the forelimb. *J. small Anim. Pract.* 1971, 12, 19—36.
- Paatsama, S., J. Jussila & I. Alitalo*: Bone changes to the legs of growing pigs induced by immobilization and overloading. *Proc. 2. I.P.V.S. Congr., Hannover 1972*, 123.

- Trueta, J. & V. P. Amato*: The vascular contribution to osteogenesis. III. Changes in the growth cartilage caused by experimentally induced ischaemia. *J. Bone Jt Surg.* 1960, *42B*, 571—587 .
- Trueta, J. & A. Trias*: The vascular contribution to osteogenesis. IV. The effect of pressure upon the epiphyseal cartilage of the rabbit. *J. Bone Jt Surg.* 1961, *43B*, 800—813.
- Vaughan, L. C.*: Leg weakness in pigs. *Vet. Rec.* 1971, *89*, 81—85.
- Walker, T., B. F. Fell, A. S. Jones, R. Boyne & M. Elliott*: Observations on leg weakness in pigs. *Vet. Rec.* 1966, *79*, 472—479.

SAMMENDRAG

Osteochondrose og arthrose hos gris. IV. Effekt av overbelastning på den distale epifyseplate av ulna.

Virkingen av overbelastning på distale epifyseplate av ulna er beskrevet. Høyre forbein hos 6 griser ble bundet opp slik at grisene gikk på 3 bein i 2 perioder, første gang i 12 dager ved ca. 50 kg levende vekt, andre gang i 7 dager ved ca. 100 kg levende vekt. Det ble utviklet osteochondrose av sterkere grad i venstre enn i høyre epifyseplate av ulna, men dette førte ikke til nedsatt lengdevekst av vesentlig grad i knoklene. Belastningen førte til en reparabel affeksjon i den distale epifyseplate av ulna. Det er sannsynlig at dette skyldes affeksjon av blodtilførselen fra metafysen, og at belastningen ikke var stor nok eller av lang nok varighet til å affisere blodtilførselen fra epifysen med derav følgende irreparable skader og tidlig lukning av epifyseplaten.

(Received September 13, 1973).

Reprints may be requested from: Trygve Grøndalen, Veterinary College of Norway, Postboks 8146, Oslo Dep., Oslo 1, Norway.