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ETIOLOGICAL FACTORS IN OSTEOCHONDRITIS DISSECANS

An Experimental Study into the Etiological Factors in Osteochondritis Dissecans in the Canine Humeral Head using Overloading With and Without Somatotropin and Thyrotropin Hormone Treatment and Mechanical Trauma

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In a previous study, the canine humeral head in the early stage of osteochondritis dissecans (o.d.) displayed irregular arrangements of cells lacking nuclei in the germinative zone of the thickened articular cartilage and an intercartilaginous cleavage with bridge formations (Paatsama et al. 1971 a). There were thick bone trabeculae subchondrally and bone regeneration. In the advanced stage a loose fragment of articular cartilage or ossified cartilage was found. In the late stage there was more granulation tissue, ossifying cartilage and new bone, and there were osteophyte formations.

The study of four growing dogs treated from the age of 6 weeks with somatotropin (500 IU), thyrotropin (94 IU) or corticotropin (1400 IU) over a period of 10 weeks revealed changes resembling the early stage of spontaneous o.d. (Paatsama et al. 1971 b). Because somatotropin and thyrotropin are known to have an influence on the articular cartilage and a stimulating effect on bone growth, the results of this latter study indicated that a changed and thickened articular cartilage, particularly in the weightbearing surface, is hardly capable of contributing to the bone remodelling and external influences during the progressive growth period.

Trauma has played an important role as an etiological factor of o.d. (e.g. Craig & Riser 1965, Leonard 1971). This same conclusion was found experimentally by Tallquist (1962). Therefore, a further study was made to investigate the etiological factors of o.d. in the canine

humeral head, using overloading and mechanical traumas of the weightbearing joint cartilage and/or bone. Overloading was used with and without somatotropin and thyrotropin hormone treatment.

MATERIAL AND METHODS

The material (Table 1) consisted of two groups of growing dogs: A) dogs having overloading with somatotropin (3 dogs) or thyrotropin (3 dogs) treatment, and overloading without hormone treatment (16 dogs) and B) a group of 13 dogs with mechanical trauma; thus giving 35 dogs in all. Fifteen dogs were used as controls: two Labradors, one treated with somatotropin and the other with thyrotropin and 13 healthy dogs (11 of them originating from the investigations mentioned in the introduction).

Group A. Six Labrador retrievers underwent myotomy of the M. biceps brachii of the right foreleg resulting in overloading of the contralateral limb. The dogs were 4 months old at the beginning of the experiment when the hormone treatment began. Three of the dogs were treated with a total dosage of somatotropin* of 500 IU and the other three with thyrotropin* 160 IU divided into equal doses and administered daily for 5 days weekly for 16 weeks. The myotomy was performed 4, 8 and 12 weeks after the beginning of the hormone treatment. The dogs were sacrificed 4, 8 and 12 weeks post-operatively, when all the dogs were at the age of 8 months. (The two hormone-treated Labradors used as controls were littermates of the previously mentioned six dogs; the hormone dosage and time of sacrifice were the same.)

The group of 16 dogs with overloading alone consisted of two Labrador retrievers and 14 mongrel dogs of medium size aged 3–6 months at the beginning of the investigation, when the myotomy was performed. The dogs were sacrificed 10–18 weeks post-operatively at the age of 8–9 months.

Group B. Mechanical trauma of the joint cartilage or joint cartilage and/or epiphyseal bone were performed on the humeral heads of 13 dogs (four Labrador retrievers and nine mongrel dogs of medium size) aged 5–6 months at the time of the operation. The traumas resembled the defects found in spontaneous o.d. The post-operative observation period was 2–18 weeks (sacrificed at 2-weekly intervals).

All dogs were kept in the Small Animal Clinic of the College of Veterinary Medicine and fed with a controlled and restricted diet of balanced dry food, canned meat, mineral and vitamin supplement.

Clinical and radiological examinations were performed at 2-weekly intervals. The specimens taken for microstructure study were sectioned in the sagittal plane after autopsy. The histological specimens were fixed in 10 per cent neutral formalin and decalcified by the EDTA method. Staining was performed with Haematoxylin-Eosin and Alcian Blue.

For oxytetracycline (OTC) fluorescence studies the dogs received oxytetracycline** i.v. 20 mg/kg body weight 2 days prior to sacrifice. The specimens to be used

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* Standardized hormones: Ferring Somacton® lagen, somatotropin 50 IU; Actyron® lagen, thyrotropin 5 IU.

** Pfizer-Terramycin®.

Table 1. Changes as a result of overloading with or without hormone treatment and mechanical trauma resembling spontaneous osteochondritis dissecans in an early stage.

Group/ number of dogs	Number/breed	Over-loading	Hormone treatment	Mechanical trauma	Age at the start (months)	Age when sacrificed (months)	Changes
A	3 Labradors	+	Somatotropin 500 IU	—	4	8	++++
(22 dogs)	3 Labradors	+	Thyrotropin 160 IU	—	4	8	+++
	2 Labradors	+	—	—	3–6	8–9	+
	14 mongrels	+	—	—	3–6	8–9	—
B	4 Labradors	—	—	+	5–6	6–10	—
(13 dogs)	9 mongrels	—	—	+	5–6	6–10	—
Controls	1 Labrador	—	Somatotropin 500 IU	—	4	8	++
(15 dogs)	1 Labrador	—	Thyrotropin 160 IU	—	4	8	++
	13 healthy mongrels	—	—	—	–	4–12	—

++++ most severe changes
+++ severe changes
++ moderate changes
+ slight changes

} Assessed radiologically, histologically, microradiologically and with OTC bone labelling.

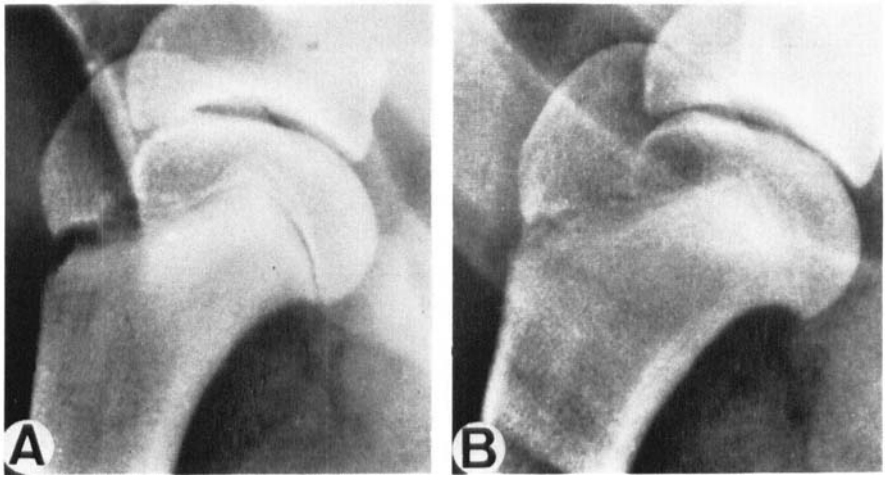


Figure 1. Radiographs of the shoulder joint of a Labrador retriever. A, at the age of 4 months at the time of commencement of somatotropin treatment. B, after 4 weeks overloading and 8 weeks somatotropin treatment showing increased radiodensity subchondrally, flattening of the humeral head and lipping of the epiphyseal margin.

in the OTC bone labelling and microradiographic studies were hardened in methylmetacrylate and ground to a thickness of 100 μ. In the microradiographic studies 22 kW and 16 mA were used along with an exposure time of 10 min and a film focal distance of 10 cm.

RESULTS

A. The dogs with overloading

Radiologically, the overloaded humeral heads of the hormone-treated dogs, particularly the three somatotropin-treated dogs showed flattening of the epiphysis, increased radiodensity subchondrally and lipping of the epiphyseal margin during an observation period of from 4–6 weeks (at an age of 20–26 weeks) (Figure 1 B). Histologically, the thick articular cartilage displayed degeneration and irregular arrangements of the cells in places, small cleavages in the germinative zone and also basally (Figure 2 A). The epiphyseal cartilage showed similar changes, metachromatically staining mass and cyst formations; the palisading columns were irregular and in places non-existent (Figure 2 B). The cartilaginous changes were more severe in the overloaded humeral head of the somatotropin-treated Labradors. Microradiography revealed thick bone trabeculae subchondrally, particularly proximally in the

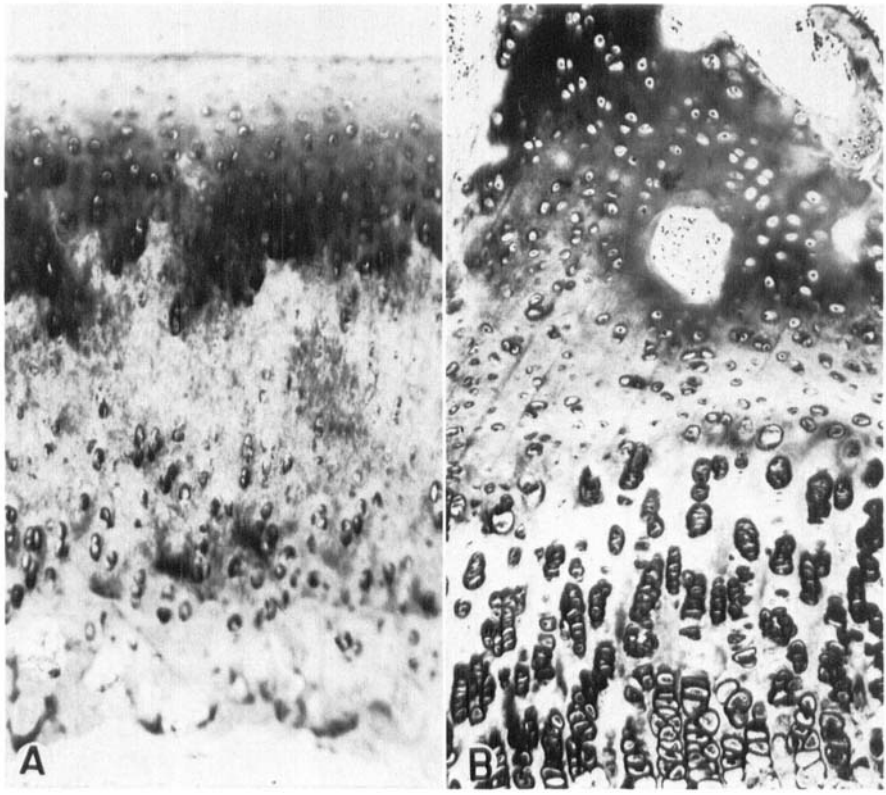


Figure 2 A & B. Micrographs of a humeral head of a Labrador retriever 8 months old (after 12 weeks overloading and 16 weeks somatotropin treatment). A, showing thick, degenerated articular cartilage, and cleavages of the germinative zone and basally. B, the corresponding changes of the geminative zone of the epiphyseal cartilage, with irregular palisading columns. Alcian Blue, × 84.

overloaded humeral head of the somatotropin-treated dogs (Figure 4 A). OTC uptake was strong subchondrally, particularly in the changed proximal area (Figure 4 B).

Radiologically, the overloaded humeral epiphyses of the two Labrador retrievers from the 16 dogs without hormone treatment displayed increased subchondral radiodensity during an observation period of from 4–8 weeks; in the 14 medium-sized mongrel dogs no such changes were observed. Histologically, none of the dogs showed any degenerative changes in the articular or epiphyseal cartilage. Microradiography and OTC bone labelling showed no changes.

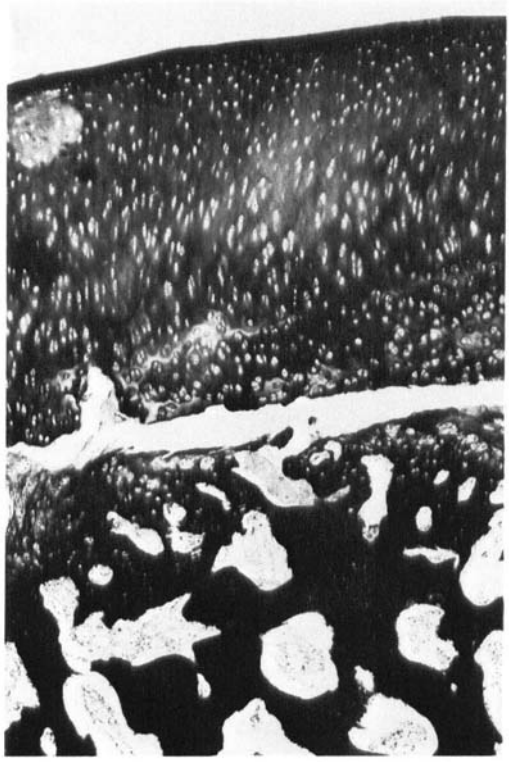


Figure 3. Micrograph of the humeral head of an 8-month-old Labrador retriever suffering from the early stage of spontaneous o.d.; thick and degenerated articular cartilage, and cleavage of the germinative zone. Alcian Blue, × 48.

B. Dogs with mechanical trauma

Radiologically, a thickening of the subchondral bone after the cartilaginous trauma was observed from 4 weeks post-operatively; the humeral heads subjected to bone trauma displayed extensive radiodensity and remodelling in the trauma area. Radiodensity of the metaphysis and uneveness of the traumatic articular surface was noted later during the observation period. Histologically, the cartilaginous trauma displayed remodelling between the traumatic and intact cartilage without signs of degeneration (Figure 5 A). The bone trauma in the humeral head showed regeneration, connective tissue, chondrocytes, cartilaginous metamorphosis and bone regeneration without signs of degeneration (Figure 6 A). Microradiography displayed thickening of the bone trabeculae subchondrally and in the metaphysis continuing towards the diaphysis, and bridge formation in the epiphyseal cartilage (Figure 7 A). In the changed areas the OTC uptake was significant (Figure 7 B). Microradiographically, the subchondral

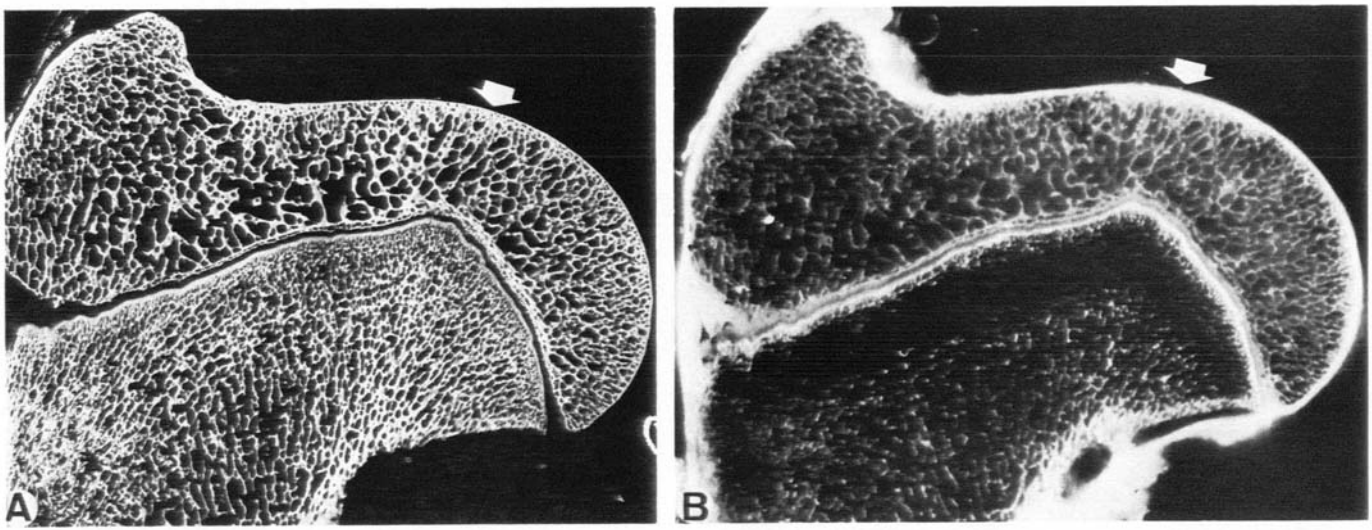


Figure 4. Microradiograph (A) and fluorescent microgrgaph (B) from the same dog as in Figure 1 at the age of 8 months (after overloading 8 weeks and somatotropin treatment 12 weeks). A, showing thickened bone trabeculae subchondrally, particularly in the proximal area (arrow). B, showing OTC uptake particularly in the proximal area.

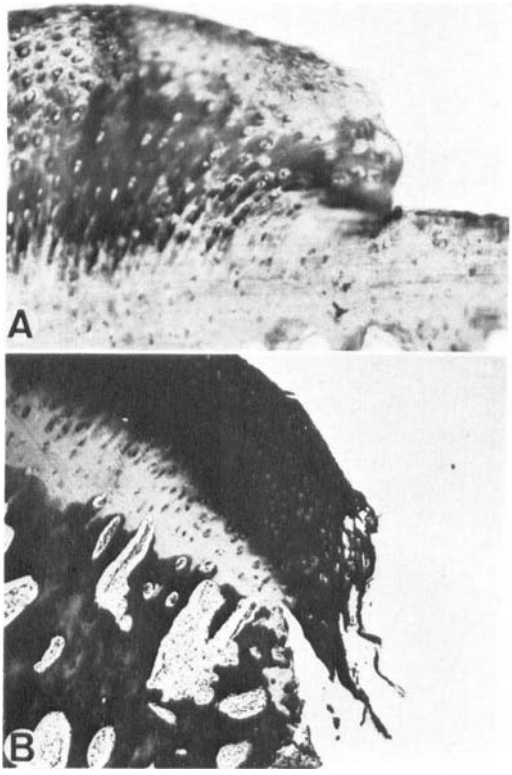


Figure 5. Micrographs: A, of the humeral head of a 9-month-old mongrel dog (the cartilaginous trauma was made 8 weeks earlier) showing a cartilaginous remodelling between the traumatic and intact cartilage. B, the same area of spontaneous o.d. showing degeneration. Alcian Blue; A × 62, B × 48.

and epiphyseal bone traumas displayed regeneration and functional remodelling (Figure 8 A & B); centrally, the bone trabeculae were in places small in number. The thick metaphyseal bone trabeculae continued towards the diaphysis and OTC uptake was strong in the changed areas.

DISCUSSION

Radiologically, the overloaded humeral heads of the six hormone-treated Labrador retrievers displayed increased radiodensity subchondrally, as well as flattening and marginal lipping at the age of 20–26 weeks (observation period of from 4–6 weeks) (Figure 1 B). Similar changes were observed in dogs suffering from spontaneous o.d. in its early stage (Paatsama et al. 1971 a). The overloaded humeral head of the two Labradors without hormone treatment showed radiodensity during an observation period of from 4–6 weeks, but no flatten-

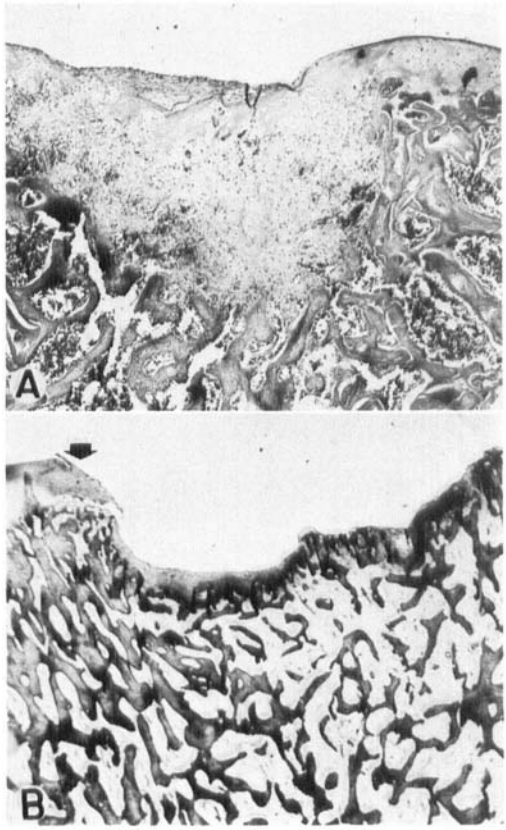


Figure 6. Micrographs: A, of the humeral head of a 9-month-old mongrel dog (the cartilaginous and bone trauma was made 16 weeks earlier) showing bone and cartilaginous regeneration and cartilaginous metamorphosis extending to the joint surface. B, spontaneous o.d.; status 10 weeks post-operatively showing bone and cartilaginous regeneration and metamorphosis, but also degeneration of joint cartilage (arrow). H-E × 24.

ing or marginal lipping. In the overloaded humeral head of the other 14 medium-sized mongrel dogs no such changes were observed. This might indicate reactive differences between the breeds of different growth characteristics, particularly when subjected to the same stress factors with similar care and feeding.

Histologically, the overloaded head of the three somatotropin-treated Labradors displayed the most severe changes: thickened and degenerated articular cartilage and small cleavages in the germinative zone and also basally (Figure 2 A) resembling changes in spontaneous o.d. (Figure 3) (Paatsama et al. 1971 a). The changes resembling spontaneous o.d. in the joint and epiphyseal cartilage (Figure 2 B) were similar in this study (eight Labradors treated with 500 IU somatotropin or 160 IU thyrotropin) to those in the earlier study by Paatsama et al. (1971 b) (four Beagle-mongrel dogs treated with 500 IU somato-

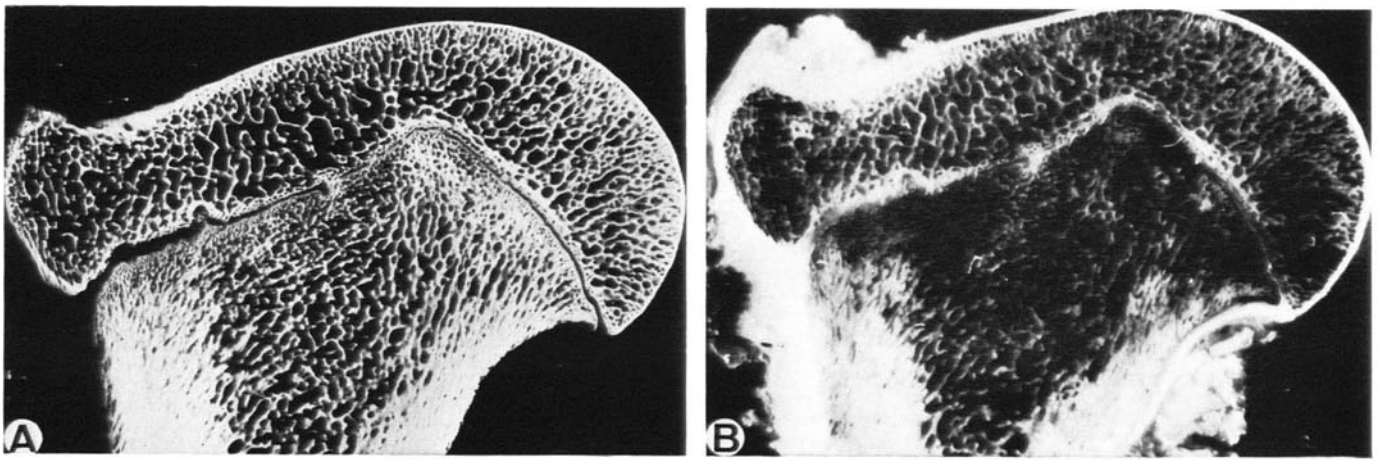


Figure 7. Microradiograph (A) and fluorescent micrograph (B) of the humeral head of a Labrador retriever, 8 months old, with mechanical trauma of the joint cartilage (8 weeks post-operatively) showing thickened bone trabeculae subchondrally and in the metaphysis continuing towards the diaphysis, and bridge formations through the epiphyseal cartilage. B, the changed areas and bridge formations show OTC uptake; a strong uptake continues towards the diaphysis.

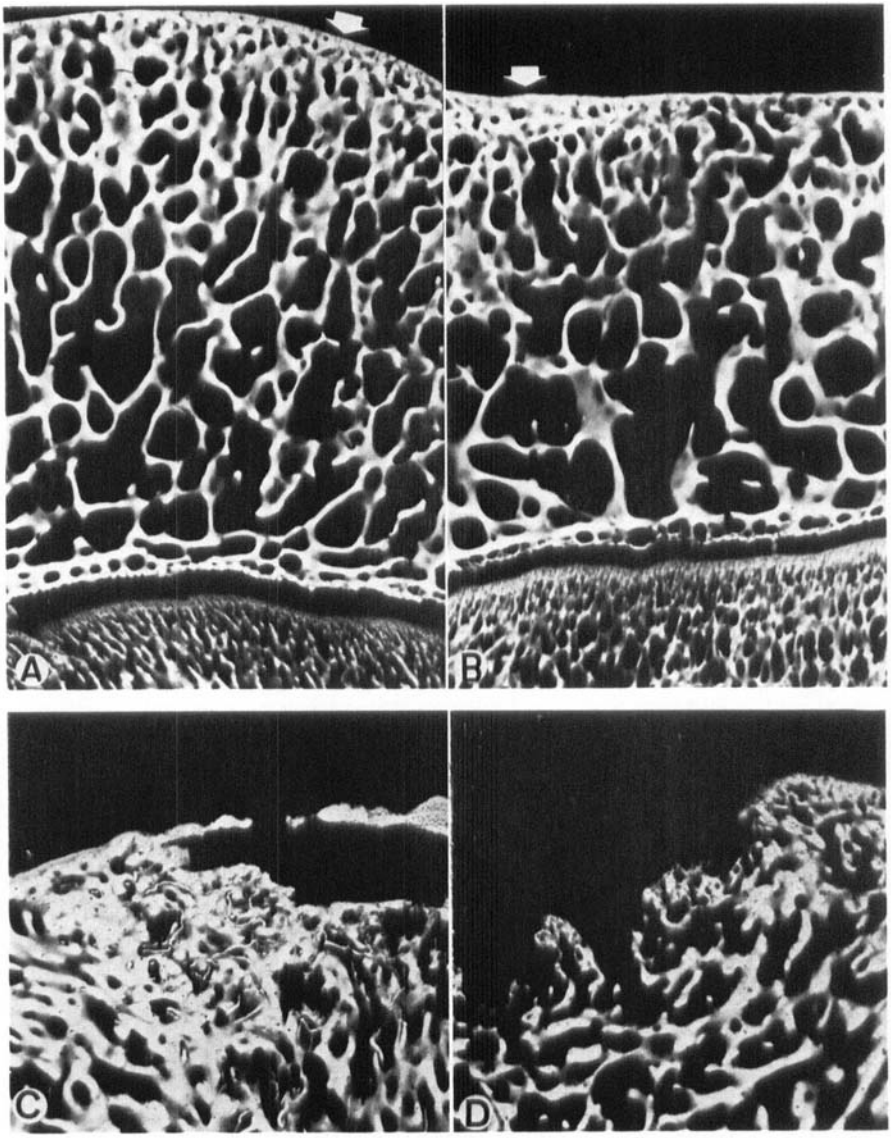


Figure 8. Microradiographs (A & B) of two mongrel dogs aged 8 months. A, the mechanical subchondral trauma made 14 weeks earlier, showing functional bone remodelling, and thickening of the bone trabeculae of a larger epiphyseal area. B, a deep epiphyseal mechanical trauma made 18 weeks earlier, showing functional healing, thick bone trabeculae and more centrally, absence of trabecular structure. C, spontaneous o.d. in an advanced (dissecans) stage and D, spontaneous o.d. 10 weeks post-operatively showing slight regeneration.

tropin, 94 IU thyrotropin or 1400 IU corticotropin) although the dogs were of different breeds and the treatment differed in total doses, and dose combinations and periods. The results further confirm the opinion that hormonal influences play an important role as an etiological factor in o.d. as discussed by Palmer (1970), Ljunggren et al. (1971) and in the earlier study (Paatsama et al. 1971 b).

Microradiologically, the overloaded humeral head, particularly of the three somatotropin-treated Labradors, displayed subchondrally a clearly distinguished area of thick bone trabeculae proximally (Figure 4 A). OTC bone labelling revealed significant uptake in the changed area, (Figure 4 B). The overloaded humeral head of the 16 dogs without hormone treatment showed no such changes. This might indicate that overloading as an external factor alone is not able to produce changes in the humeral head; a changed tissue (internal factor, in this study caused by hormone treatment) is also needed. Why the overloading produced changes more proximally and not in the place of spontaneous o.d. was probably due to the fact that this wearing point of the joint surface became more highly stressed.

Radiologically, the mechanical trauma of the articular cartilage and/or epiphyseal bone showed the most prominent changes; viz. increased radiodensity subchondrally, in the bone trauma area and in the metaphysis. During the observation period the bone traumas resulted in regeneration without signs resembling spontaneous o.d. Histologically, the mechanical trauma of the joint cartilage showed remodelling between the traumatic and intact cartilage (Figure 5 A) and no degeneration as in spontaneous o.d. (Figure 5 B). The bone traumas displayed extended cartilaginous and bone regeneration (Figure 6 A) similar to the slight healing process of spontaneous o.d. and cartilaginous degeneration (arrow, Figure 6 B). Microradiographically the humeral head with cartilaginous trauma displayed thick bone trabeculae subchondrally, and in the epiphysis and metaphysis (Figure 7 A). The changed areas showed OTC uptake continuing towards the diaphysis as a sign of regeneration and functional remodelling (Figure 7 B). The subchondral and deeper epiphyseal bone traumas showed functional healing and remodelling (Figure 8, A and B), differing from that in spontaneous o.d. (Figure 8, C and D). The mechanical traumas in the humeral heads of all the 13 operated dogs did not result in changes resembling those of spontaneous o.d. as observed by Tallquist (1962) in an experimental study in the rabbit knee joint.

SUMMARY

The overloaded humeral heads of the six growing Labrador retrievers treated with somatotropin and thyrotropin hormone showed the most pronounced changes of the articular cartilage and subchondral bone, resembling changes in the early stage of spontaneous osteochondritis dissecans. The overloading alone used in 16 dogs without hormone treatment produced no changes, except that two Labrador retrievers showed increased radiodensity subchondrally during the first 4–6 weeks of the observation period. The mechanical traumas of the articular cartilage and the epiphyseal bone regenerated and did not result in changes resembling those of spontaneous osteochondritis dissecans.

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