Articular Cartilage of Experimental Hip Dysplasia

by

Kosuke Ogata, M. D.

Department of Orthopedic Surgery Faculty of Medicine,
Kyushu University, Fukuoka 812, Japan

Perry L. Schoenecker, M. D.

John and Evelyn Orthopedic Research Laboratory
Washington University School of Medicine

Degenerative arthritis of the hip is a frequent outcome of congenital hip dysplasia.¹²⁾ In completely dislocated joints, it is likely that the articular cartilage undergoes degeneration due to loss of pumping action of the joint surfaces which is important for the cartilage nutrition²⁾⁷⁾. On the other hand, in subluxated joints, cartilage degeneration may be induced by abnormal biomechanical forces applied to limited areas of the joint surfaces. For experimental models of osteoarthritis, immobilization, compression or sectioning of ligaments have been frequently used and their effects on the articular cartilage have been described in detail⁴⁾⁵⁾⁹⁾¹⁰⁾¹¹⁾. However, only a few studies are found concerning the effects of joint dislocation and subluxation on the articular cartilage⁸⁾.

The purpose of the present study is to observe histologic and histochemical changes of articular cartilage of dislocated and subluxated hips in the growing dogs.

Materials and methods

His dysplasia was produced in the growing puppy by immobilizing one of the hind limbs in a straight leg plaster cast with the knee in complete extension⁹⁾. The casts were initially applied when the puppies were approximately 4-6 days of age and changed every 5-6 days or replaced whenever a puppy lost his cast.

Roentgenograms of both hips were taken in the first 2 weeks of life and repeated approximately every 4 weeks. Hip stability was assessed with the Barlow's maneuvers¹⁾ at the time of the initial cast application and with each cast change thereafter. Immobilization was discontinued after approximately 12 weeks of casting when dysplasia of varying severity was established as noted on physical and roentgenographic examinations.

The animals were subsequently sacrificed at approximately 3, 6 and 12 months of age following the cessation of casting. The acetabuli, intra- and extra-capsular soft tissues and proximal femurs were dissected comparing the normal and dysplastic hips of each dog. The acetabuli and proximal femurs were decalcified, sectioned and stained with hematoxyline-eosin and Safranin-O for microscopic examination.

Results

Roentgenographic examination at the time of sacrifice revealed subluxation of the femoral head in two animals at 3 months, 2 at 6 months and 3 at 12 months. Complete

Fig. 1: The dislocated femoral head was smaller in size than the normal head and showed a characteristic deformity with the medial portion being flattened and the superior lateral portion being protruded. Note severe reduction of Safranin-O staining and hypocellularity (Safranin-O, $\times 3$).

Fig. 2: The superior dome of the acetabulum was found to be shallow. Note marked pannus proliferation over the articular surface (Safranin-O, $\times 3$).

Table 1. Modified histologic-histochemical grading

Structure	Grade	Safranin-O-staining	Grade
Normal	0	Normal	0
Surface irregularities	1	Slight reduction	1
Pannus and surface irregularities	2	Moderate reduction	2
Pannus or clefts to transitional zone	3	Severe reduction	3
Pannus or clefts to radial zone	4	No dye noted	4
Pannus or clefts to calcified zone	5		
Complete disorganization	6		
Cells		Tidemark integrity	
Normal	0	Intact	0
Diffuse hypercellularity	1	Crossed by blood vessels	1
Hypocellularity or cloning	2		
Acellularity	3		

dislocation was noted in one animal at 3 months, 3 at 6 months and 2 at 12 months. Among the dislocated hips included those which were initially subluxated and gradually developed complete dislocation.

The dislocated femoral head was smaller in size than the normal head and showed a characteristic deformity with the medial portion being flattened and the superior lateral portion being protruded (Fig. 1). Acetabulum was found to be shallow with marked pannus formation over the articular surface (Fig. 2).

In studying the histologic changes of the articular cartilage of the dysplastic hips, the grading system described by Mankin and co-authors⁶⁾ was used to compare the severity of the osteoarthritic changes of the subluxated and the dislocated hips. The grading system was slightly modified as shown in Table 1 in the present study. The grades varied considerably from site to site in the areas studied from femoral head and acetabular cartilage. The area with the most severe lesion was selected from femoral head and acetabulum and the grading scores from each area were averaged to evaluate severity of the osteoarthritic

Fig. 3: The average histologic and histochemical gradings of the subluxated and dislocated hips at the follow-up of 3, 6 and 12 months. Note significant degenerative changes in the dislocated hips which appears to have progressed with duration of the dislocation.

Fig. 4: Photomicrograph of the articular surface of the dislocated femoral head. Note pannus proliferation over the surface and cystic degeneration in the middle zone (Safranin-O, $\times 120$).

changes in the entire hip joint. Only slight degenerative changes were found in the hips with subluxation. No progression of degenerative changes was noted in one year follow-up. On the contrary, completely dislocated hips showed significant degenerative changes which appeared to have progressed with duration of the dislocation (Fig. 3).

Characteristic microscopic findings of the articular cartilage in the dislocated hips were severe reduction of Safranin-O staining, fibrocartilaginous proliferation and hypocellularity. The articular surface of the dislocated hip was frequently covered by a pannus-like tissue and in the middle zone of the cartilage cystic degeneration was often found (Fig. 4). The normal arrangement of the chondrocytes was usually disorganized in the dislocated hip, however, chondrocyte cloning and cleft formation were seldom observed.

Discussion

The degenerative changes of the articular cartilage in the dislocated hip appeared to mimic those found in the immobilized joints³⁾⁴⁾¹⁰⁾. In both situations, fibrocartilaginous proliferation and severe reduction of Safranin-O staining are characteristic findings while chondrocyte cloning and cleft formation are rarely seen.

Since joint motion with normal pumping action of the articular cartilage may be one of the most important factors to facilitate the provision of adequate synovial nutrition to the cartilage²⁾³⁾⁷⁾, it may be reasonable to think that cartilage degeneration in the immobilized or dislocated joints is caused by the decreased rate of diffusion of the nutrients.

In this study, subluxated hip did not show significant degenerative changes in one year follow-up. However, it is expected that the more advanced degenerative changes develop in the future with the longer follow-up. In contrast with the subluxated hip, the dislocated hip developed significant degeneration early in the present investigation.

Our results suggest that the dislocated joint should be reduced at the earliest oppor-

tunity to minimize possible degenerative changes of the articular cartilage.

Summary

Immobilization of the hind limb in a straight leg cast produced hip dysplasia of varying degrees in the growing puppy. Only slight degenerative changes were found in the hip with subluxation. No progression of degenerative changes was noted in one year follow-up. Completely dislocated hips showed characteristic deformity of the femoral head and severe acetabular dysplasia. Significant cartilage degeneration was noted which appeared to have progressed with duration of the dislocation. Characteristic changes were severe reduction of Safranin-O staining, fibrocartilaginous proliferation (pannus formation) and hypocellularity.

References

- 1) Barlow, T. G.: Early diagnosis and treatment of congenital dislocation of the hip. *J. Bone Joint Surg.*, 44-B; 292, 1962.
- 2) Ekholm, R.: Articular cartilage nutrition. How radioactive gold reaches the cartilage in rabbit knee joint. *Acta Anat., Supplementum* 15, 1951.
- 3) Enneking, W. F., and Horowitz, M.: The intra-articular effects of immobilization on the human knee. *J. Bone Joint Surg.*, 54-A: 973, 1972.
- 4) Evans, B., Eggers, G. W. N., Butler, J. K. and Blummer, J.: Experimental immobilization and remobilization of rat knee joint. *J. Bone Joint Surg.*, 42-A; 737, 1960.
- 5) Hulth, A., Lindberg, L., and Telhag, H.: Experimental osteoarthritis in rabbits. Preliminary report. *Acta Orthop. Scand.*, 41: 522, 1970.
- 6) Mankin, H. J., Dorfman, H., Lippiello, L., and Zarin, A.: Biochemical and metabolic abnormalities in articular cartilage from osteoarthritic human hips. *J. Bone Joint Surg.*, 53-A; 523, 1971.
- 7) Maroudas, A., Bullough, P., Swanson, S. A. V., and Freeman, M. A. R.: The permeability of articular cartilage. *J. Bone Joint Surg.*, 50-B; 166, 1968.
- 8) Michelsson, J. E., and Langenskiöld, A.: Dislocation or subluxation of the hip, regular sequels of immobilization of the knee in extension in young rabbits. *J. Bone Joint Surg.*, 54-A; 1177, 1972.
- 9) Ogata, K., Whiteside, L. A., Lesker, P. A. and Simmons, D. J.: The effect of varus stress on the moving rabbit knee joint. *Clin. Orthop.*, 129: 313, 1977.
- 10) Ogata, K., Whiteside, L. A. and Andersen, D. A.: The intraarticular effect of various postoperative managements following knee ligament repair: An experimental study in dogs. *Clin. Orthop.*, 150; 271, 1980.
- 11) Salter, R. B. and Field, P.: The effects of continuous compression on living articular cartilage. An experimental investigation. *J. Bone Joint Surg.*, 42-A; 31, 1960.
- 12) Sokoloff, L.: *The Biology of Degenerative Joint Disease*. Chicago, University of Chicago Press, 1969.

質 問

長大整形 岩崎 勝郎

亜脱臼例における関節軟骨の変化は、変性の修復も増悪もしなかったとのことであるが、これらはどのように解釈すればいいか。

が、関節軟骨の変化は、ほとんど見つかることはできなかった。ただし、follow-upを1年以上見て行けば、何らかの変化が見られるものと思う。又、1年以内でも、電顕レベルでの変化が起っていることも考えられる。

回 答

九大整形 緒方 公介

亜脱臼群では Acetabular dysplasia は見られた

回 答 (新宮先生へ) 九大整形 緒方 公介 tion を行ったところ、骨頭の血流はほとんどなくな
大腿骨頭の栄養動脈に関する実験を、以前犬を用い った。このことから、lateral retinacular vessel
て行ったが、その際、lateral retinacular dissec- の重要性がうかがわれた。

~~~~~