An Experimental Study of the Epipysis, with Special Reference to the Retardation and Stimulation of Growth.

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AN EXPERIMENTAL STUDY OF THE EPIPHYSIS, WITH SPECIAL REFERENCE TO THE RETARDATION AND STIMULATION OF GROWTH.*

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This paper is presented to the American Orthopedic Association as a preliminary report of research experiments I am now carrying on, in the hope of throwing some light upon the subject of epiphyseal growth, with special reference to its retardation and stimulation, as seen in disturbances about the epiphyseal line. My attention was first directed to the subject by seeing in the practice of Dr. E. G. Brackett the following case:

CASE I.—B. W., age thirteen; first seen May 5, 1903. The patient gave a history of a crushing injury to his right knee received three years before. This injury resulted in an open wound. Under treatment the child received good motion. During the last two years a knock-knee gradually developed, along with an abnormal ability to hyperextend the knee. For this last condition the patient sought advice.

Physical Examination.—The patient showed rather marked knock-knee and some laxity of the capsular ligaments. The right leg was two and one-fourth inches shorter than the left. When recumbent, with knees together, the inner malleoli were five and one-fourth inches apart. Because of this increasing deformity operation was advised and radiograms were taken. (See reproductions, Case I, A and B.)

May 8, 1907.—An osteotomy was performed above the condyles, and the leg was put up in plaster in an overcorrected position. Convalescence from operation was uneventful.

*Read by invitation before the American Orthopedic Association, at Hartford, June, 1909.
August 12, 1907.—A slight relapse was noted. The capsular ligaments were relaxed.

November 9, 1907.—The deformity was increased.

February 20, 1909.—One year and nine months passed since first osteotomy. The deformity had increased in spite of the most careful apparatus treatment, and the patient was again operated.

Fig. 1.—Case I. A.—Note lack of growth of external condyle.

Operation.—An osteotomy just above the epiphyseal line of the external condyle was done, special care being taken not to displace the cortex of the inner side of the shaft. The leg was put in plaster in an overcorrected position. The convalescence has so far been uneventful.

This injury was received and treated during the period of the
child's most active growth. The relapses which occurred in the case were, I believe, due in the first place to a cessation or inhibition of growth from the epiphyseal line of the external condyle. Or they may have been due to the continuance of the normal growth of the inner condyle, with a possible stimulation from the trauma to the outer condyle. The comparative overgrowth of the inner condyle can be seen in the radiograms (Case I). Altogether, this case seems to present, then, retardation in growth, due to excessive
injury; and possibly stimulation of growth, from a near-by trauma. The case still presents two questions: Will any more relapses

 occur? And cannot something be done to stimulate the growth of the external condyle?

In order to study the effects of fracture through the epiphyseal
line, the following experiments have been conducted upon rabbits varying from three to five weeks old, since this is the youngest age possible to operate without excessive mortality. In all experiments the technic of careful surgical asepsis was used. All rabbits were etherized.

Series I.—Through an incision one inch long, just within the patella, the joint capsule was incised, the patella displaced outward, and, by means of a knife, a complete separation of the inner condyle was made along the epiphyseal line. The capsule was sewed with catgut, and the skin with catgut. The leg was put up in plaster. Thirty-six rabbits were operated on, in the last twelve of which the fracture was done subcutaneously. Early in these experiments it was evident that plaster dressings were too
great a strain upon the rabbits, and a decreased mortality resulted when sterile dressings only were applied. The animals in this series are still being watched, and individuals will be killed at intervals. At least one year longer will be necessary to complete this series, which was begun in September, 1908. It is hoped that the experiments will result in giving us a clearer idea of the

retardation of growth which takes place on the injured side, and the unretarded or stimulated growth of the uninjured side of the knee.

**Case II.**—B. S., age five years. Seen in practice of Dr. Brackett in September, 1903. The child at that time had developed an acute tubercular spine, which was rapidly followed by a tubercular process in one knee that required an incision. The condi-
tion subsided, and the patient began to walk. But there slowly developed as a complication, a knock-knee. In 1908, five years after the onset, the child showed a marked knock-knee, requiring surgical interference. Radiograms were taken. (See reproduction, Case II, A, B, and D.)

This case seems to illustrate the stimulation to growth. This

stimulation to growth is seen often in the tubercular processes in knee and hip-joints, and I believe it represents a juxta-epiphyseal disease, which, by the action of its toxins, along with the inflammatory reactions, is stimulating the epiphyseal line. Subsequent extension of the disease through the epiphyseal line, may explain the final retardation of growth often seen later in these cases.

Fig. 6.—Case III. A.—Osteomyelitis of the tibia near epiphysis.
To study this stimulation of growth from lesions near the epiphyseal line, the following experiments were conducted upon rabbits, under aseptic conditions, and with the use of ether.

*Series II.*—Incision was made just above the adductor tubercle of the right leg, exposing the bone. A small drill hole was made just above the epiphyseal line of the inner condyle. By this means a piece of copper, two-tenths of a centimeter long, was inserted into the diaphysis of the inner condyle, the wound closed with catgut, and sterile dressing applied. This copper, acting as a foreign body, will produce an osteomyelitis. Will this sequestrum with its resulting reaction stimulate the growth of the inner condyle? To illustrate this experiment clinically I shall cite briefly a case reported by Dr. Goldthwait in 1901.

![Fig. 7.—CASE III. B.—After operation in which a sequestrum was removed and growth of leg stopped.](image-url)
CASE III.—M. F., child seen in 1900. Following measles there rapidly developed an osteomyelitis of the left tibia.

Radiogram shows osteomyelitis of the upper end of the left tibia with a sequestrum. Later radiograms show the extension of the disease, along and through the epiphyseal line into the epiphysis. (See radiograms, Case III, A and B). In this year, 1900, the cavity was opened. Discharge continued through the sinus.

November 7, 1901.—Left leg was five-eighths of an inch shorter than the right.

November 5, 1902.—Legs were of equal length.

July 2, 1903.—Sinus curetted and sequestrum removed.

September 14, 1907.—Six years after the onset. Left leg one inch shorter than the right, showing a retardation amounting to one and three-eighths inches since the removal of the sequestrum in October, 1903.

This case shows the effect of stimulation, which it is hoped will be simulated in the copper-wire experiments, and also by the following series.

Series III.—Operative technic similar to that used in Series II. Instead of copper-wire, staphylococcus vaccine was injected into the small drill hole above the epiphyseal line of the inner condyle, and the hole plugged with wax. This will produce an osteomyelitis. Since the use of the above means might not prove safe clinically, some experiments have been performed on rabbits by using ivory bone plugs. In several cases of infantile paralysis, Dr. Goldthwait has used ivory plugs, and although it is early yet to report these cases, in two of them the affected leg has kept pace with the unaffected leg during the growing age of the child.

Series IV.—Twelve rabbits were operated on with the usual technic. A small ivory plug, about two-eighths of an inch, was driven through the cortex of the femur, just above the epiphyseal line of the inner condyle. Clinically, as well as experimentally, the important point in this procedure is to select the proper location for the ivory plug, special care being taken not to damage the epiphyseal line.

Another interesting epiphyseal condition is epiphyseal displacement. What effect does displacement of the epiphysis have upon the growth of that part?

Series V.—Seventeen rabbits were operated on and the epiphysis of the inner condyle of the femur displaced, and then partially reduced, and the leg put up in sterile dressing.

Series VI.—Twelve rabbits were operated on with the usual technic. The epiphyseal line of the inner condyle was excised in
toto, and the condyle displaced upon the diaphysis. By observing this series, it is hoped to determine the exact part which the epiphyseal line plays in the growth of bone.

The clinical cases cited show that the growth supposed to take place at the epiphyseal end of the diaphysis is influenced by disease and trauma.

The experiments upon rabbits have been conducted with a hope of determining answers to the following questions:

1. At what point and from what cells does the growth of bone take place?
2. Can this growth be retarded?
3. Can this growth be stimulated artificially?

A solution of these questions may open a new field in operative surgery. Most of the rabbits used in these experiments have to be observed from six to nine months. Numerous microscopical preparations must be made and radiograms taken. To complete the report, one or two years more will be required.
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