Gross Changes Produced by Traction Force in the Long Bone of Rabbit

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Summary

Effects of traction on long bone growth in 30 rabbits were studied by applying traction in the long axis of right tibia. Animals were divided into three equal groups: experimental, sham-operated and control group. Radiography was used to measure the initial and final lengths of tibia. In experimental group traction to the tibia was applied by a method discussed later on. Lengths of tibiae, measured on radiographic films, did not show any significant change in the length of right tibia as compared to those in the experimental group.

Introduction

Except for minor contribution by enchondral ossification of epiphysis itself, longitudinal growth of bone is primarily function of the growth plate. Affections of bone growth, therefore, are essentially those of the growth plate.[6]

Activity of growth plate chondroblast is genetically predetermined.[7] This activity of growth plate is controlled by endocrine glands;[6] but there are certain local factors which influence the bone growth. That the growing bone is plastic, in sense that its growth may be controlled by pressure, has been known for centuries.

Various bone deformations, produced by artificial means such as elongated skulls of ancient Egyptians and familiar Chinese bound foot deformity, attest to this quality of bone increased pressure parallel to axis of epiphyseal growth inhibiting its growth.[3]

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Decreased pressure, parallel to the axis of epiphyseal growth, will accelerate growth (Volkman).[1] Most of the former authors have decompressed the growth plate by doing some surgical procedure on the tibia itself, such as drilling the bone, incising the periosteum etc.

Present study was planned to observe the effects of growth plate decompression on growth of tibia in rabbits, by applying traction in the long axis of bone, without giving any surgical trauma to the bone itself.

Material and Methods

Thirty rabbits, each of 6 weeks of age (just after weaning) were obtained from animal house for the study. All these animals were divided into three groups. Each group was further divided into two subgroups. Each subgroup had 5 animals. Animals of group A were experimental, of group B were sham-operated and animals of group C were kept as control.

Numbering of animals was done by punching their ears and also by writing the number on the inner aspect of pinna of the ear by a marker.

To record initial lengths of both tibiae, animals were prepared for radiography. They were anaesthetized by injecting Nembutol intraperitoneally in doses of 35 mg/Kg body weight and continued by Ether. Radiography was done at tube-plate distance of 70 cm.

For applying traction to tibia, Kirschner wire was to be passed through the right femoral condyle. It was required to cut both collateral ligaments of the knee joint because they are attached below the epiphyseal plate of tibia. Also to overcome the strong compressive force of gastrocnemius muscle, tendo-calcaneous of the right side had to be incised. A plaster of paris boot was applied to the right foot. Then the animals were transferred to the cages especially designed for this purpose. Right foot was tied to floor of the cage. A string was attached to the Kirschner wire in the femoral condyle by a U-clip. This string was then passed over a pully above the roof of the cage. A weight equal to $\frac{1}{3}$rd of the body weight was tied to the other end of the string. Traction to the upper epiphyseal plate was through the cruciate ligaments of the knee and to the lower epiphyseal plate was through the collateral ligaments of ankle joint.

Animals in the sham-operated group B were similarly operated and their feet were fixed but no traction was applied. Animals of the group C were not operated and kept as a control group. Alizarine Red S, a biological stain, was used to study the bone growth. This stain combines with calcium in the blood ıd is deposited with this calcium in the bone and colours it red. A total of ıree injections of Alizarine (4%) were given to animals in group, A, B and C, in ɔses of 100 mg/Kg body weight intraperitoneally. First injection was given on :t day of the experiment, second injection on 10th and third on 20th day of the :periment. On 22nd day, animals were sacrificed and both tibiae of all the aniials were isolated. Bones were numbered in pairs, right sided tibia was marked ʳ curling a metalic wire around it. Then the bones were fixed in 10% buffered rmalin for 48 hours. After this, the bone pairs were placed on radiographic ates, appropriately numbered and re-radiographed for measurement of the final ıgths of tibiae.

:sults

Mean values of the initial lengths of right and left tibiae of the same ɔup were compared. The differences were very small and statistically non signiant (Table I).

TABLE I

COMPARISON OF THE MEAN VALUES OF RIGHT AND LEFT TIBIAL LENGTHS OF THE SAME GROUP RECORDED BY RADIOGRAPHY AT THE START OF EXPERIMENT

ɔup	No. of animals	Mean length of right tibia (cm)	Mean length of left tibia (cm)	Statistical significance of the difference between right and left tibiae
	3	6.55 ± 0.42	6.56 ± 0.41	P > 0.05
	5	6.99 ± 0.17	7.02 ± 0.18	P > 0.05
	4	5.85 ± 0.48	5.18 ± 0.48	P > 0.05
	2	6.55 ± 0.45	6.55 ± 0.45	P > 0.05
	5	6.60 ± 0.20	6.61 ± 0.19	P > 0.05
	5	6.40 ± 0.22	6.41 ± 0.23	P > 0.05

Mean values of right and left tibial lengths of the same group were ıpared at the end of experiment. There was statistically no significant change tibial length of right side as compared to the left in experimental and other ɹps (Table II).

At the end of experiments, mean values of right tibial lengths of Aliıne-treated and non-Alizarine-treated groups were compared. Gain in length of t tibia in non-Alizarine-treated groups was slightly more as compared to Aliıe-treated groups. The differences were statistically non-significant (Table III).

TABLE II

COMPARISON OF THE MEAN VALUES OF RIGHT AND LEFT TIBIAL LENGTHS OF THE SAME GROUP RECORDED BY RADIOGRAPHY AT THE END OF EXPERIMENT

Group No.	No. of animals	Mean length of right tibia (cm)	Mean length of left tibia (cm)	Statistical significance of the difference between right and left tibiae
A1	3	7.17 ± 0.67	6.90 ± 0.5	P > 0.05
A2	5	7.24 ± 0.22	7.20 ± 0.20	P > 0.05
B1	4	6.50 ± 0.51	6.40 ± 0.46	P > 0.05
B2	2	7.32 ± 0.47	7.17 ± 0.42	P > 0.05
C1	5	7.13 ± 0.14	7.11 ± 0.16	P > 0.05
C2	5	7.14 ± 0.25	7.13 ± 0.26	P > 0.05

TABLE III

COMPARISON OF MEAN VALUES OF TIBIAL LENGTHS OF ALIZARINE TREATED AND NON ALIZARINE TREATED GROUPS A1, A2, B1, B2 AND C1, C2 AS RECORDED BY RADIOGRAPHY AT THE END OF EXPERIMENT

——— RIGHT SIDE ———

Alizarine treated group	No. of animals	Mean length of right tibia (cm)	Non Alizarine treated group	No. of animals	Mean length of right tibia (cm)	Statistical significance of the difference
A1	3	7.17 ± 0.67	A2	5	7.24 ± 0.22	P > 0.05
B1	4	6.50 ± 0.51	B2	2	7.32 ± 0.47	P > 0.05
C1	5	7.13 ± 0.14	C2	5	7.14 ± 0.25	P > 0.05

4. At the end of experiment, mean values of left tibial lengths of Alizarine-treated and non-Alizarine-treated groups were compared. Length of left tibia was slightly more in non-Alizarine-treated groups as compared to left tibia of Alizarine-treated groups. The differences were statistically non-significant (Table IV).

5. There were no statistically significant differences between tibial lengths of groups A1, A2, B1, B2 and C1, C2. Therefore data on length of tibia was pooled and the groups were renamed as A, B and C. Right tibial lengths at the end of [illegible]

TABLE IV

COMPARISON OF MEAN VALUES OF TIBIAL LENGTHS OF ALIZARINE TREATED AND NON ALIZARINE TREATED GROUPS A1, A2, B1, B2 AND C1, C2 AS RECORDED BY RADIOGRAPHY AT THE END OF EXPERIMENT

——— LEFT SIDE ———

Alizarine treated group	No. of animals	Mean length of left tibia (cm)	Non Alizarine treated group	No. of animals	Mean length of left tibia (cm)	Statistical significance of the difference
A1	3	6.9 ± 0.5	A2	5	7.2 ± 0.20	P > 05
B1	4	6.4 ± 0.46	B2	2	7.2 ± 0.42	P > 05
C1	5	7.1 ± 0.16	C2	5	7.1 ± 0.26	P > 05

TABLE V

COMPARISON OF MEAN VALUES OF RIGHT TIBIAL LENGTHS BETWEEN GROUPS A, B AND C AS RECORDED BY RADIOGRAPHY AT THE END OF EXPERIMENT

Group No.	No. of animals	Mean length of tibia (cm)	Group No.	No. of animals	Mean length of tibia (cm)	Statistical significance of the difference
A	8	7.16 ± 0.23	B	6	6.57 ± 0.40	P > 0.05
A	8	7.16 ± 0.23	C	10	7.13 ± 0.14	P > 0.05
B	6	6.57 ± 0.40	C	10	7.13 ± 0.14	P > 0.05

6 Left tibial lengths of group A, B and C at the end of experiment were compared with each other. The differences were statistically non-significant (Table VI).

In present study, no statistically significant change in length of tibia under traction was noted. Force of traction, applied for three weeks, was equal to $\frac{1}{3}$rd of body weight. Structures which might have resisted traction on tibia such as collateral ligaments of knee and tendocalcaneous, were cut except quadriceps tendon, only structure which might have resisted the force of contraction. Above findings failed to support the hypothesis that traction in long axis of the bone was expected to result in accelerated growth.

TABLE VI

COMPARISON OF MEAN VALUES OF LEFT TIBIAL LENGTHS BETWEEN GROUPS A, B AND C AS RECORDED BY RADIOGRAPHY AT THE END OF EXPERIMENT

Group No.	No. of animals	Mean length of tibia (cm)	Group No.	No. of animals	Mean length of tibia (cm)	Statistical significance of the difference
A	8	7.08 ± 0.21	B	6	6.67 ± 0.35	$P > 0.05$
A	8	7.08 ± 0.21	C	10	7.12 ± 0.15	$P > 0.05$
B	6	6.67 ± 0.35	C	10	7.12 ± 0.15	$P > 0.05$

These findings are in contrast with the findings of Hert[4]. He succeeded to accelerate growth of tibia by applying traction only to proximal epiphysis of tibia for 3 months with a force equal to ½ of body weight. In his set up, a Kirschner wire was passed through the epiphysis and another through diaphysis. He pulled these Kirschner wires apart by using spring distractors, whose tension was regulated daily. He had 26% more gain in length of tibia as compared to its counterpart. These positive results may be due to more force and longer duration of time. Also trauma to epiphysis may have resulted in hyperaemia of the bone which resulted in acceleration of growth.

In present study, no operative procedure was done on tibia and also less force and shorter duration of time may be the cause of failure to accelerate growth.

Grilly,[2] and Warrell and Taylar[7] found that circumferential incision of periosteum resulted in growth plate decompression. They noted significant change in length of chicken radius and rat tibia, after 17 days and 34 days of operation respectively. The positive results of the research workers might be due to faster rate of growth in these animals and also trauma to the periosteum might have accelerated the growth plate activity.

Ring[5] succeeded to elongate the bone in puppies. He applied subcutaneous clamps to epiphysis and diaphysis and pulled them apart with such a force that it caused separation of epiphysis from diaphysis. Elongation attained was due to ossification of the haematoma. In this study acceleration of growth was not the cause of elongation. But in our present study, pull was not applied to separate epiphysis and diaphysis apart.

Anyhow besides physical effects of traction on the long bones, histological aspects need further research work and elaboration.

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