THE ROLE OF THE PERIOSTEUM IN THE GROWTH OF LONG BONES

AN EXPERIMENTAL STUDY IN THE RABBIT

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Hemicircumferential division of the periosteum was performed on the upper tibia of the rabbit. Division of the medial side regularly caused a valgus angulation, but other injuries about the upper tibia had no effect. The cause of deformity after periosteal damage is discussed.

Circumferential division of the periosteum is known to increase the rate of growth of long bones by increasing the activity of the growth plate (Crilly 1972; Warrell and Taylor 1976). It is not known whether partial division causes selective stimulation of growth with consequent angular deformity. The following experiments on animals were designed to study activity

and at weekly intervals thereafter. Comparable views were obtained by ensuring a standard distance of 50 centimetres from the tube to the plate and by using a specially constructed jig, designed to obtain an accurate and reproducible position of the tibiae (Fig. 7). Changes in growth were determined by measuring the angle between the proximal growth plate and the tibial shaft—the P-S angle (Fig. 8). One animal from each group was killed at two-weekly intervals to allow histological assessment of the growth plate.

Figure 1—Periosteum divided below the pes anserinus. Figure 2—Division of periosteum and pes anserinus. Figure 3—Periosteum divided above pes anserinus. Figure 4—Division of pes anserinus only. Figure 5—Osteotomy of fibula. Figure 6—Division of lateral periosteum.

of the growth plate after partial periosteal division and other injuries about the upper tibia of the immature rabbit.

MATERIAL AND METHOD

Six-week-old New Zealand White rabbits, weighing between 1015 and 1790 grams (mean 1301 grams), were chosen as the experimental animal. Twenty-four animals were used and divided into six groups of four. The following experiments were performed on the upper tibia in each group: medial hemicircumferential division of the periosteum below the pes anserinus; medial hemicircumferential division of the periosteum and division of the pes anserinus; medial hemicircumferential division of the periosteum above the pes anserinus; division of the pes anserinus alone; division through the metaphysis of the fibula alone; lateral hemicircumferential division of the periosteum (Figs. 1 to 6). One animal sustained damage to the epiphysis at the time of operation with subsequent epiphysiodesis. It was therefore excluded from the series.

The right leg was selected as the experimental side and a sham procedure dividing the skin and superficial tissue only was performed on the left side in each case. Radiographs were taken before operation

RESULTS

The results were recorded graphically by plotting the mean P-S angle on both operated and control sides at weekly intervals. Repeated radiographs and measurements showed that estimation of the P-S angle was consistent to within 1 degree.

Fig. 7

Jig for securing rabbit for radiographs.

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Medial hemicircumferential division of the periosteum below the pes anserinus created a significant valgus deformity (Fig. 9) which persisted over the whole experimental period of eight weeks. Division through the pes anserinus and the medial periosteum induced an early valgus deformity with secondary compensation in the distal shaft (Fig. 10). Medial hemicircumferential periosteal division above the pes anserinus had a similar

Fig. 8

The angle between the growth plate and tibial shaft (P-S angle).

effect (Fig. 11). Figures 12, 13 and 14 are graphs of the P-S angles in these three experiments. Division of the pes anserinus alone did not produce any measurable angular deformity. Similarly, division of the fibula or of the lateral periosteum of the tibia did not show any measurable change in the P-S angle.

Microscopical study of the growth plates did not show any abnormal features. The width of the growth plate on the experimental side was similar to that on the

Fig. 9

Fig. 10

Fig. 11

Radiographs at two weeks. Figure 9—Periosteal division below the pes anserinus. Figure 10—Division through the pes anserinus and periosteum. Figure 11—Division above the pes anserinus.

control side, and cellular orientation and maturation appeared normal.

DISCUSSION

It is well-known that complete circumferential division of the periosteum stimulates longitudinal growth of bone (Crilly 1972). It is now clear from the above experiments that the periosteum influences activity of the growth plate. They show that hemicircumferential division of the periosteum stimulates the growth plate on the same side and induces angular deformities. Other traumatic insults near the knee do not involve the periosteum of the tibia and do not have this effect, as shown by the negative results of division of the pes anserinus and fibula alone. Hemicircumferential division of the lateral periosteum similarly has no effect on growth, probably because of the tethering effect of the intact fibula, which restrains the lateral tibial growth plate.

Whether the stimulation is due to interruption of

Fig. 12

Fig. 13

Fig. 14

Graphs of P-S angle. Figure 12—Periosteal division below the pes anserinus. Figure 13—Division through the pes anserinus and periosteum. Figure 14—Division above the pes anserinus. ●, Control side; ○, experimental side.

the metaphysial blood vessels (Wray and Goodman 1961) or mechanical release of the periosteal restraint on the growth plate (Crilly 1972) is not known. The periosteum is loosely attached to the diaphysis of the tibia, but has a strong connection at the perichondral ring. Moreover, the thick periosteum of young bone has an inherent elasticity (Van der Sandt 1977) and probably exerts a constant mechanical restraint at both ends of the bone. Partial circumferential division of the periosteum at any level in the metaphysis releases tension and affects the growth plate similarly. As a different vascular insult would be inflicted at each level and therefore affect the growth plate differently, the mechanical theory would seem most probable.

The divided periosteum is reconstituted rapidly in rabbits (Van der Sandt 1977) and this probably accounts for the secondary correction of the deformity.

We are unable to explain the failure of remodelling after partial periosteal division below the pes anserinus. However, this site of periosteal division is analagous to greenstick fracture of the upper tibia in children. This injury leads to persistent valgus of the upper tibia (Cozen 1953; Weber 1977).

It would seem, then, that partial periosteal division may have a place in the treatment of angular deformities in children in preference to more major operations such as epiphysial stapling, epiphysiodesis or corrective osteotomy, with their unpredictable results.

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