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THE ROLE OF PETAL TECHNIQUE IN ACTIVATION OF OSTEOGENESIS

An experimental study

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During the last six years, the standard treatment of delayed and non-union of fractures of long bones at the SMS Medical College Hospital, Jaipur, has been the use of the "petal technique" combined with modified Phemister's bone grafting procedure. Clinical observations suggested that by addition of this technique, the union was quicker and the callus radiologically appeared more abundant and structurally superior. The results were so impressive that it was decided to carry out an experimental study to evaluate the efficacy of petal technique under controlled conditions. The term "petal" describes a piece of bone elevated from the cortex in such a manner as to leave its base attached to the parent bone (Figure 1).

MATERIAL AND METHODS

This study was carried out in 23 albino rats, male and female, weighing 100–150 g. During the period of study one limb was used as the test limb with the other limb serving as control in the same animal. Intraperitoneal sodium pentobarbital 3 mg/100 g body weight was used for anesthesia.

On the control side anteromedial and anterolateral surfaces of tibia were exposed, and near the tibial prominence a hole was drilled through the cortex into the medullary canal of the tibia. The bone was divided transversely distal to the tibial spine with a knife blade. A stainless steel pin was pushed through the drilled hole into the tibia across the fracture site to achieve immobilization. Comminution at the fracture site was always avoided, and if it occurred the rat was discarded from the experimental series. On the test side 6–8 petals were raised proximal and distal to the fracture site on the lateral and medial surfaces before causing the fracture with a knife.

All the animals were subjected to the same controlled diet and environmental conditions. They were divided into four groups and were sacrificed 12, 20, 30 and

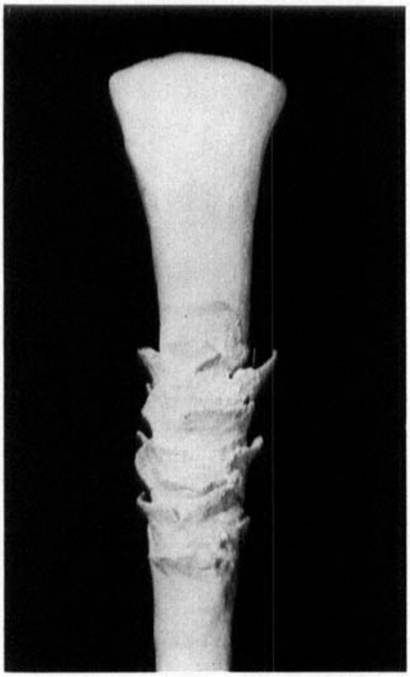


Figure 1. Plaster of Paris model of tibia showing "petals" raised from original cortex.

40 days postoperatively, i.e., Group 1 (12 days); Group 2 (20 days); Group 3 (30 days); and Group 4 (40 days).

The tibiae were dissected out, and under fairly strict control of radiological constants X-rays were taken. Density, volume of callus and periosteal reaction proximal and distal to the fracture site were closely observed. Resorption of cortex near the fracture line was also noted. After X-rays the intramedullary pin was removed and tensile strength (breaking load) was measured. It was designed to find out the weight necessary to break the union at the fracture site under carefully controlled conditions, as described by Jarry & Uhthoff (1960). Weights were added in increments of 50 g until the fracture recurred. Histological studies were undertaken on the specimens ½ cm proximal and distal to the fracture site. Haematoxylin and Eosin staining techniques were used for regular studies and for collagen tissue Van Gieson staining technique was used. Longitudinal sections showing callus across the fracture site could not be obtained because all the tibiae were subjected to tensile strength test.

OBSERVATIONS

Radiological:

The control side in Group 1 (12 days) showed relatively less callus, with some cortical thinning. The test side showed more callus and its continuity was more marked. The cortical thinning near the fracture

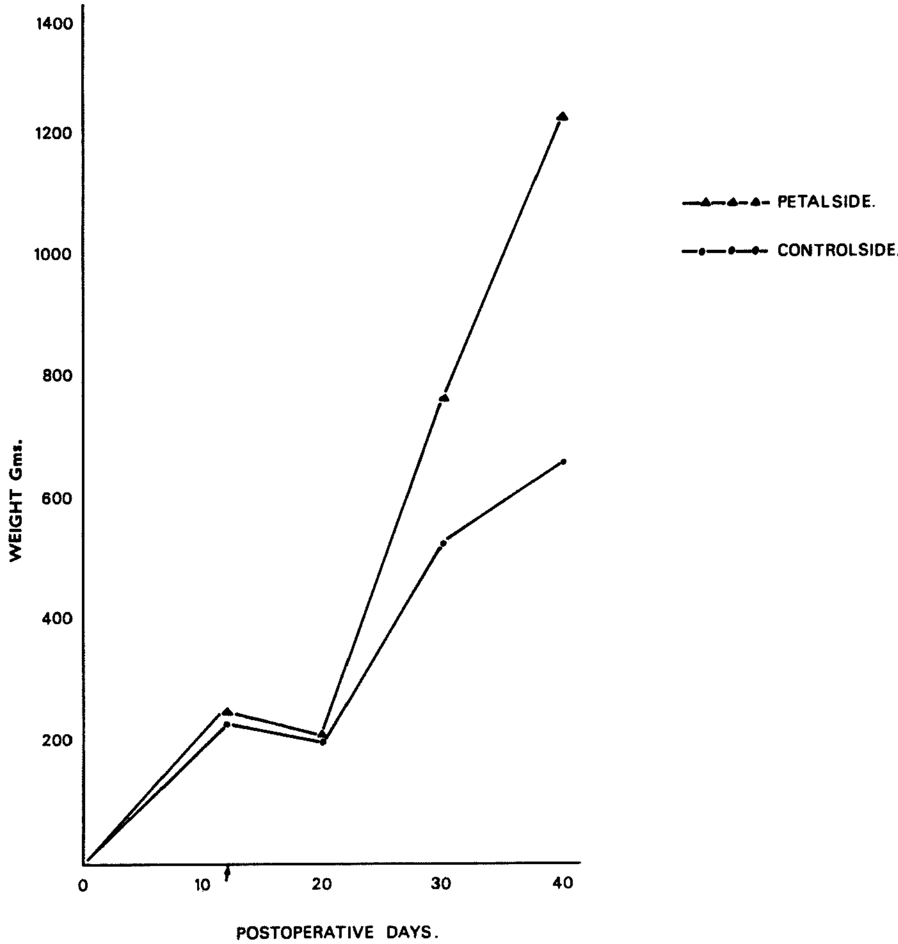


Figure 2. Shows mean values of weights required for breaking the bone near the fracture site on the petal and control sides. Note the drop in strength in Group 2, and sharp rise in strength in Groups 3 and 4.

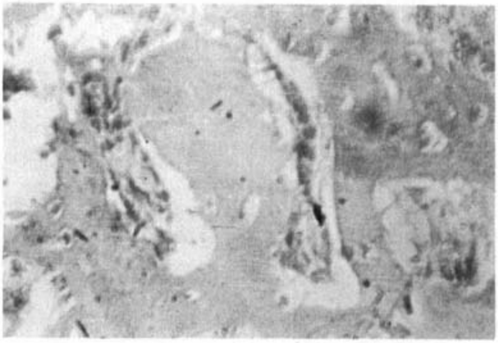
site was more pronounced. The density of callus on the two sides and the periosteal reaction showed no significant difference. In Group 2 (20 days) when compared to the control side, the fracture gap on the test side was less visible and the callus appeared to be denser and more compact. Cortical thinning at the fracture site and the periosteal reaction were also more pronounced.

Group 3 (30 days): The test side showed only a faintly visible fracture gap, much less than the control side, and the callus appeared to be denser and better fixed to the cortex. Again definite superiority of union on the test side was noticed in Group 4 (40 days). The fracture line was barely visible on the test side. A good amount of dense callus well fixed to the cortex was seen in all the cases. There was also evidence of remodeling of shape.

Tensile strength test:

The mean of weights required to break tibiae in Group 1 on the control side was 239 g as compared to 249 g on the test side. In Group 2 there was no significant difference in their absolute and mean values. In fact, these values were lower than the ones in the previous group, control/test 201:211. At 30 days in Group 3, a difference of 243 g in mean values was noticed in favor of test side, 773 g compared to control 530 g. A 90 per cent increase in tensile strength on the test side as compared to the control was evident in Group 4—Test/control 1237:660—mean difference of 577 g (Figure 2).

Figure 3. Shows base of petal attached to original cortex, petal is surrounded by newly forming callus suggesting its osteogenetic potential.



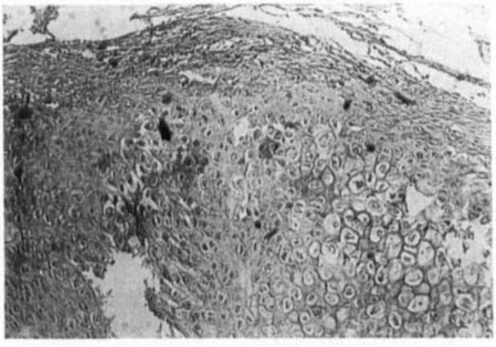


Figure 4. (Group 2 control side) Showing periosteum and fibrocartilagenous callus. Scanty osseous tissue.

Figure 5. (Group 2 petal side) – Compared from Figure 4. Abundant osseous callus with mature fibroblasts.

Histological:

Group 1. The control side showed a moderate amount of callus. The striking feature was the high cellularity with plump and immature fibroblasts. Many islands of cartilaginous matrix were seen with very little osseous tissue. The callus was poorly anchored to the original cortex with little evidence of cortical activity. Collagen tissue was scanty. On the test side, callus was abundant and better fixed to the cortex. The fibroblasts appeared more mature. Although there were islands of cartilaginous matrix, osseous tissue was increased, compared to the control side. In a few slides, petals could be easily identified by their density identical to the original cortex and the direction of their fibers; some petals were also seen surrounded by callus, suggesting osteogenetic potential (Figure 3).

Group 2. Poorly fixed callus with loose-packed, immature fibroblasts was seen on the control side, and cartilaginous islands dominated the picture with only small areas of osseous tissue. On the test side the callus was abundant and firmly fixed to the cortex. There was evidence of cortical resorption and revascularization. Most of the cells were mature fibroblasts and the osseous matrix dominated the picture (Figures 4 and 5).

Group 3. The control side still showed many islands of cartilaginous matrix, immature fibroblasts, and few patches of osseous tissue. On the test side, more maturation of osseous matrix and areas of calcification were noticed. Cartilaginous tissue was sparse. Collagen was more prolific than on the control side (Figures 6 and 7).

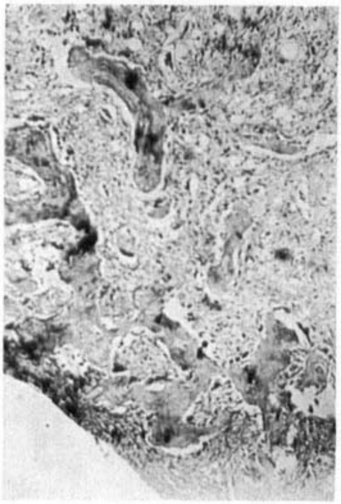


Figure 6. (Group 3 control side) – Fibrocartilagenous callus. Small osseous islands.

Figure 7. (Group 3 petal side) – Mature osseous callus with moderate cellularity. Some areas of bone mineralization.

Group 4. Some increase in the bulk of collagen tissue and improvement in the fixation of callus to the original cortex was seen on the control side, but there was still a predominance of cartilaginous tissue. The test side showed a significant increase in osseous matrix and calcified zones. Some cartilaginous islands in the transitional phase to mineralization with poor cellularity were noticeable. Collagen tissue was adequate on the test side as compared to the control.

DISCUSSION

To study the comparative results of a treatment in relation to fracture union, it is essential that, as far as possible, there be no extraneous factors which may affect the process of fracture healing. This ideal is difficult if not impossible to achieve in clinical practice. In the

Table 1. Statistical evaluation of stability test.

Days	Group	No. of animals	Mean difference	Standard error of mean difference	90 % confidence interval for μ the true mean difference	95 % confidence interval for μ the true mean difference
12	1	5	10	17.88	$\mu <$	
20	2	6	10	37.14	$\mu <$	
30	3	5	243	30.822	$\mu > 194$	$\mu > 178$
40	4	6	577	83.66	$\mu > 442$	$\mu > 418$

Column 4 indicates the mean difference in breaking strength of the two sides. Column 6 gives lower bound for the true mean difference, which in 90 % of the cases will be exceeded.

Last column gives for animals sacrified after 30 and 40 days, a lower bound of 178 g and 418 g as the true mean difference between the two sides in favor of petal technique, with a probability of 95 %.

experimental laboratory this problem can be reduced to two variables: (1) fracture healing in normal course, and (2) fracture healing with the addition of the "petal" technique. In the present study an attempt was made to keep all other factors constant by producing identical fractures at the identical site by an identical method. A clean division with a knife was preferred, as force used to produce fracture manually could not be adequately controlled. Hormonal factors influencing osteogenesis were cancelled out by using both male and female animals. Petal technique was used alternately on the right and left side; thus each animal served as its own control. Immobilization of fracture site was achieved by using stainless steel intramedullary pins applied similarly to the control and test side. The healing process continued under identical physical, nutritional and hormonal influences.

In the present study the quality of callus was decided by: (1) radiologic evidence, (2) histologic evidence, and (3) tensile strength, resulting from healing of fracture as a function of time. All the above parameters were found favorable on the petal side in all the cases. Bourne (1944) has shown that overproduction of callus is often in inverse proportion to its quality. In the present study the quality of the abundant callus on the test side was found superior radiologically, mechanically, and histologically.

The radiologic findings were in accordance with the findings reported by Jarry & Uhthoff (1960); the decalcification and revitalization of cortex was always more pronounced on the petal side. The callus on the petal side was superior in quality depending upon its volume, density, adherence to the cortex, and appearance of fracture gap.

Anatomically, healing of fracture may be observed by radiographic or histological examination, but neither of those two methods measures the functional state of fracture site. The tensile strength test was undertaken to assess the mechanical strength of callus at the fracture site. Weights required to break the test and control side were almost identical and the mean difference had no significant value in Group 1. The overall inferiority of mechanical strength of the callus in Group 2 over that of Group 1 can be attributed to the shrinkage of callus, revascularization and thinning of the cortex. This observation is supported by the findings of McKeown et al. (1932) who reported a sharp loss of strength between 15–21 days by 40 per cent, possibly attributing it to some chemical factor responsible for destroying the units of calcified mass. Definite evidence of difference in strength was observed in Groups 3 and 4. At 30 days there was a mean difference of 243 g in favor of the test side. At 40 days there was 90 per cent superiority on the test side (1237 g) over that of the control side (660 g). In no instance did the bone break at a site other than the fracture site, suggesting that the fusion had not occurred completely.

According to clinical observations, oblique and comminuted fractures lead less often to nonunion than transverse fractures. Cretin (1940) explained this on the grounds of an increase in contact area of fracture site with the surrounding soft tissues. He also suggested that the increased surface area of fracture influenced osteogenesis favorably by: (1) throwing into action a larger number of osteogenetic cells, (2) by providing a larger area for anchorage of callus, and (3) by facilitating revascularization. In petal technique, the term petal describes a piece of bone elevated from the cortex in such a manner as to leave its base attached to the parent bone. The technique provides: (1) increase in surface area of fracture and an increase in the contact area with the surrounding soft tissue, (2) wider and better anchorage of callus, and (3) more rapid decalcification and revitalization of the cortex at the fracture site by reducing its thickness. Petalling represents a directed trauma with a definite osteogenetic potential. Harris (1957) explained that by cutting petals the thickness of the cortex is diminished, thus diminishing the time when the cortex will be revascularized and reorganized into living bone. By separating the cortex into thin petals a surface is provided which will be filled in by new bone and will give a much greater area for the attachment of callus, and more rapid revascularization and reorganization of these flakes.

From time to time attempts have been made to induce delayed and nonunion fractures to unite by procedures in which bone graft is not required. The role of bone transplants in favorably influencing osteogenesis is still obscure. Conflicting views have been put forward: (1) does the transplant actively participate in the process of osteogenesis, or (2) does it merely act as a passive scaffolding for new bone to be laid down, or (3) does it act as a ready source of calcium? These questions have been debated for a long time (Siffert 1955, Ray 1956, Burwell 1966, Urist 1953). An entirely different explanation has been put forward by Danis (1966) and Jarry & Uhthoff (1960) suggesting that the transplants act simply due to the reaction caused by the trauma of the preparation of the bed for the graft. In the treatment of delayed and nonunion fractures "petalling" can be usefully added to Phemister bone grafting, in which the osteogenetic potential of cancellous bone graft can be combined with that of petalling, leading to firm union in the area of fibrocartilaginous bridge of fracture gap, and thereby avoiding the risks of fracture of donor site and the loss of cortical graft from infection. Based on the same concept, McElvenny (1963) advised the use of "fish scaling" (similar to petal technique) in arthrodesis of the knee. Prophylactically this procedure can be used during open reduction and internal fixation of fresh or old fractures of long bones to reduce the chances of delayed union which could result from intramedullary nailing, and thus lessen the total period of morbidity.

Addition of "petalling" to any of the above procedures would not increase the magnitude of operative shock or trauma. It would increase the operative time insignificantly if at all. This study suggests that the tensile (breaking) strength is significantly accelerated by use of this technique. It is not suggested that this technique will produce end results better than the other techniques. It is suggested from this study that by use of this technique, patient morbidity can be decreased.

SUMMARY

This paper describes a simple surgical procedure for stimulating osteogenesis by the use of "petal technique". This procedure is applicable in open reductions for the treatment of transverse or short oblique fractures. By increasing the contact area of the fragments with the surrounding tissues, by promoting anchoring process at the fracture

site and by biological changes of the compact bone, acceleration of the fracture consolidation is achieved. These facts have been established by radiological, histological and tensile strength studies conducted in 23 rats. The advantages of this method are: (1) simple surgical procedure, (2) it does not increase surgical trauma or shock, (3) it hastens the healing process at the fracture site.

The present study suggests that the use of this simple technique can significantly reduce morbidity in selected cases.

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