The effects of gradual dynamization on fracture healing

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The verified conditions of fracture healing are: vascularity of the injured bone, repositon of the fracture and proper casting. Opinions about casting and stabilization have been changed in the course of time.

There has been gradual development. At the beginning external fixation, splints and casting, then constant extension, later stable compression osteosynthesis were used. Nowadays elastic internal fixation is thought to be the best solution. All these methods mean non-changing stabilization from the beginning of the treatment to complete healing.

To reach a constant biological stimulus on fracture healing during treatment, the degree of fixation should gradually be reduced, dynamized. Furthermore, the question if gradual dynamization should be only axial or complex has not been answered yet. In addition to this, we've got positive clinical experiences about single dynamization, but we miss comparative examinations, objective methods to verify the right degree of stabilization and the effects of dynamization.

In my study I compared the effects of 3 different methods of casting/splinting (A: permanently stable, B: gradually dynamized, C: gradually stabilizing).

I created standardized conditions on femurs of rabbits by osteotomy in the 3 groups. I examined the 'fractures' of 5 rabbits in each group in the course of week 3, 4, 5 and 6. I used external fixation and influenced the stability of the bars by changing the number of the 5 connecting Kirschner-wires. In advance, I checked the stability of the fixators by load test.

Control methods

Control measurings happened once a week. I measured the following factors:

- the electric voltage of tissue metabolism and the resistance of the tissues;
- the weights of the rabbits;
- the quantity of the callus (per week) by vital dyeing in hard segments (polychrome sequens-marked hystomorphometria);
- sizes and density of the osteons;
- the signs of healing on x-rays of the femurs.

I used planimetry to measure quantity of the callus, changes in the periphery and density of the callus. Furthermore I compared the fracture resistance of prepared femurs and the non-injured sides and recorded sound emission during loading the femurs. In this lecture I'll evaluate the histological segments, the x-rays and the measurement results of flexibility strength of the callus.

Results

I recorded the evaluation results numerically and this method offered the possibility of biostatistical (correlation and significance) calculations.

In the hard segments I recorded the diameter of the osteons; the surface of differently coloured osteon rings that had developed in a week's time and the number of osteons to be seen in a visual field of a 0.25 square millimetre. The surface growth of the rings decreased exponentially in all of the 3 groups.

Most callus developed in group C. (In both A and B the quantities were smaller.) The difference between group C and group A or B was significant in the course of week 2. The number of osteons in group A was significantly higher than in groups B and C in week 2 and 3; there was no statistical difference in the rest of the weeks. As for the number of osteons, group A contained significantly more osteons – there were no more differences between the groups.

The x-rays of the femurs were evaluated by 3 experienced specialists. They classified the healing process in 5 categories. The specialists considered the healing process of group B to be significantly better (α=0.05). The findings began to get closer to each other in weeks 5, 6 and 7. Group C seemed to be significantly worse compared to group A in weeks 6 and 7.

The prepared femurs were submitted to a 3-point flexibility test loaded by a speed of 2.5 mm/minute on a 4-centimetre section; comparing the healthy and the 'broken' side in the same way. The stability in group B was significantly better in weeks 3, 4, 5, 6 and reached the domain of health. The difference between groups A and C developed as late as in week 7 for group A.

Discussion

The experimental model provided equivalent local conditions for fracture healing. The only variable was the stability of fixators. This factor made it possible for us to compare the effects of different kinds of stabilization without any restrictions. The measure of stability and the pace of the changes were chosen arbitrarily. These factors were only guided by the known total time of healing, and they followed also the possibilities of the fixator's structure . I think that complex-direction stability changes get closer to the mechanism of the biological stimulus in the tissues than an exclusive one-direction axial loading-model does[3,5].

If healing means for the patient to regain load-bearing, continuous dynamization (group B) can shorten time of the healing process in rabbits by 2 weeks – compared to constant stability fiixation (group A). In the reciprocal group (group C) I could not verify that increasing fixation (that is continuous reduction of mechanical stimulus) had curbed healing process. As this group starts out with flexible fixation (2-wire bars), in histological segments – compared to stable groups – the healing process begins to produce higher quantities of callus and a rougher osteon structure. The reduction of stimulus probably results in decreased calcification some weeks later, so the callus produces a relatively lower stability, weaker bone scar.

The stable conditions in groups A and B at the beginning start with developing identical histological structures (osteon sizes and density). The advantages of gradual dynamization turn up after week 3 (group B). These advantages come probably from the optimal structure and quality of collagen fibres and the earlier formation of apatite.

Accepting the results given, implant development should be directed towards absorbing – that is gradually dynamizing – fixation. On this way, the axial mechanical stimulus accompanying the present-day implantates can only represent an intermediate phase.

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