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TIBIAL FRACTURES TREATED WITH HOFFMANN'S EXTERNAL FIXATION

A Comparative Analysis of Hoffmann Bilateral Frames and the Vidal-Adrey Double Frame Modification

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The results after treatment of 50 open and comminuted tibial fractures with Hoffmann's external fixation were analysed. Half of the fractures were treated with bilateral Hoffmann frames, the other half with the Vidal-Adrey double frame modification. The groups were found to be comparable.

The results of the study confirm that Hoffmann's external fixation is a safe method for treating the bone and soft tissue lesions in such fractures. There was only one case of osteomyelitis, no definite pseudarthrosis and no leg amputation.

The considerably increased stability of the Vidal-Adrey double frame modification did not reduce the length of the healing period compared to fractures treated with bilateral Hoffmann frames. The duration of external fixation was on average 24 weeks, and the radiological healing time 27 weeks.

A slightly greater number of residual deformities were found in the group treated with bilateral Hoffmann frames. Most of the deformities were so minor, however, that they were of little practical consequence for the patients. Thus it seems that the original Hoffmann apparatus, if duplicated, is a stable enough fixation in most cases.

Key words: fracture fixation; tibial fractures

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Open and comminuted tibial fractures are difficult to treat. During the last 10 years good results have been reported using Hoffmann's external fixation device (Vidal 1968, Olerud 1973, Vidal et al. 1976, Karlstrøm & Olerud 1977, Connes 1977, Burny 1979, Lawyer & Lubbers 1980).

Hoffmann presented his equipment as early as 1938 (Hoffmann 1938). However, because of infection around the fixation screws and in some cases delayed or non-union of the fracture, the method gained a somewhat poor reputation. These adversities have been attributed to a lack of stability.

Ray (1964) improved the stability by duplicating the fixation device, and Professor Vidal (Vidal 1968) in Montpellier further improved the stability considerably by introducing a double frame system.

Vidal's co-worker Adrey made a biomechanical study of the stability of various mountings of the Hoffmann device in tibial fractures. This study confirms that the double frame is the most rigid mounting (Adrey 1971).

At the Orthopaedic Department, Trondheim University Hospital, Hoffmann's device was first employed in the treatment of open and comminuted tibial fractures in 1974, and until 1977 bilateral Hoffmann frames were used (Figure 1). From 1977 the Vidal-Adrey modification with a

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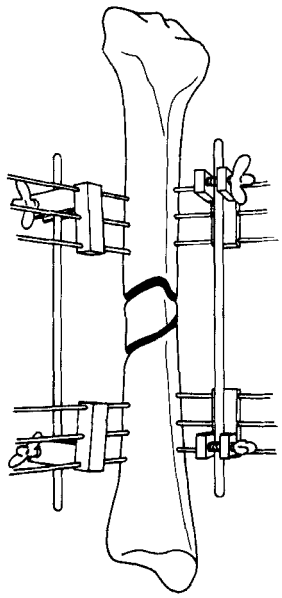

Figure 1. The bilateral Hoffmann frames with three Hoffmann screws inserted laterally and medially into each fragment, at an open frontal angle of 110 degrees.

double frame was introduced and this is the method that is used today (Figure 2).

To our knowledge no comparative study of the clinical results of the bilateral Hoffmann frames and the Vidal-Adrey modification has been presented. The aim of this study is to analyse retrospectively whether the considerably increased stability gained by the double frame mounting gives a shorter healing time and generally better treatment results in open and comminuted tibial fractures.

PATIENTS AND METHODS

From January 1974 until March 1980, 50 tibial fractures in 48 patients have been treated with external fixation; until November 1977, 25 fractures with bilateral Hoffmann frames and from April 1977, 25 fractures with the Vidal-Adrey modification with a double frame. One patient in each group had a bilateral tibial fracture where both fractures were treated with external fixation.

The entire material consisted of 31 men and 17 women. The age distribution was 7–73 years, on average 40 years in the group treated with bilateral Hoffmann frames and 44 years in the group treated with the Vidal-Adrey method.

Thirty-six patients were injured in road accidents, 9 in accidents at work, one in a hang-glider accident and two patients fell in the street.

Twenty-seven patients had other injuries besides the tibial fractures, 14 in the group treated with bilateral Hoffmann frames and 13 in the group treated with the Vidal-Adrey method. Fifteen out of these 27 patients had a head injury (8 with serious brain damage) and 6 patients had a femur fracture.

The fractures were classified according to Bauer et al. (1962). Five fractures were transverse or short oblique (45°–90°); of these, 4 were in the group treated with bilateral Hoffmann frames. Three fractures were long oblique, all in the group treated with the Vidal-Adrey method. The rest, 42 fractures, were comminuted (intermediate fragment involving at least half of the bone diameter), 21 in each group.

Thirty-four fractures were located in the diaphyseal part of the tibia only; 20 of these were in the group treated with the Vidal-Adrey method. Ten fractures affected both the diaphysis and the proximal metaphysis; 4 of these were treated with the Vidal-Adrey method. Six fractures affected both the diaphysis and the distal metaphysis, of which one was treated with the Vidal-Adrey method.

Thirty-eight fractures were open, 19 in each group. The damage to skin and soft tissue was graded from I–III; grade I represents skin perforation from within, grade II a wound longer than 2 cm which probably represented a perforation from without and grade III laceration of skin and muscle caused by a direct trauma (Matter 1970). Three fractures were grade I, 23 grade II and 12 grade III. The grade III fractures were equally distributed between the two groups.

Additional procedures are shown in Table 1. Twenty-five of the 38 wounds were closed primarily. Secondary bone grafting was performed in 7 patients, in most

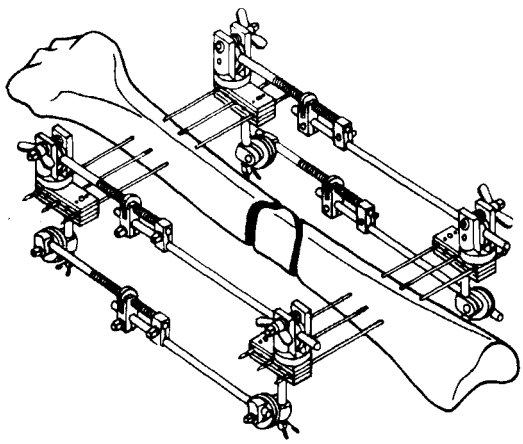

Figure 2. The Vidal-Adrey modification with double frame mounting.

Table 1. Additional procedures required in 50 tibial fractures treated with external fixation

	Bilateral Hoffmann frames $n=25$	Vidal-Adrey method $n=25$	Total material $n=50$
Primary wound closure	14	11	25
Split-skin graft	2	5	7
Myoplasty		2	2
Cross-leg		1	1
Primary bone grafting	3	1	4
Secondary bone grafting	3[a]	4[b]	7
Calcaneal traction before external fixation	11[c]	4[d]	15
Prophylactic antibiotic treatment	15	15	30

a. After 4–34 weeks, on average 17 weeks.
b. After 2–27 weeks, on average 11 weeks.
c. On average 17 days.
d. On average 4 days.

cases late in the healing course. In summary, the two groups are comparable with regard to most of the parameters.

For all patients the x-rays and the clinical records have been studied. Furthermore, 35 patients with 37 tibial fractures attended a special follow-up examination, 18 patients (19 fractures) in the group treated with bilateral Hoffmann frames and 17 patients (18 fractures) in the group treated with the Vidal-Adrey method. The follow-up time was a minimum of 1 year in the clinical study. In the group treated with the original Hoffmann apparatus the average follow-up time was 4 years and 10 months; in the group treated with the Vidal-Adrey method 2 years and 4 months.

At the follow-up examination the ability to walk and the range of movement of the knee, ankle and tarsus were studied. Possible skin problems and rotational deformities were registered. Angulation deformities and shortening were measured roentgenologically.

In evaluation of residual joint stiffness Nicoll's criteria (Nicoll 1964), modified by Slätis & Rokkanen (1967), were used.

Knee joint:
Good: Full extension, flexion not limited by more than 10°.
Fair: Any loss of extension or loss of more than 10° of flexion.
Poor: Inability to flex the knee to 90°.

Ankle joint:
Good: Loss of flexion or extension less than 25 per cent.
Fair: Loss of flexion or extension 25–50 per cent.
Poor: Loss of flexion or extension more than 50 per cent.

Tarsus:
Good: Loss of inversion or eversion less than 25 per cent.
Fair: Loss of inversion or eversion 25–50 per cent.
Poor: Loss of inversion of eversion exceeding 50 per cent.

RESULTS

Healing

There was no difference between the two groups regarding the duration of fixation and the roentgenological healing time (Table 2) or the time until full weight-bearing without external support was allowed (mean: 34 weeks).

Only one fracture which had been fixated with the Vidal-Adrey double frame had been exactly reduced. The healing of this fracture was found to be predominantly cortical. All the other fractures healed with periosteal callus formation.

Complications

There was only one leg with a deep wound infection complicated by osteomyelitis in the whole material (2 per cent). None of the pin infections led to serious problems. Peroneal palsy was found in two patients treated with the Vidal-Adrey method. However, in neither of these patients

Table 2. Duration of fixation, and roentgenological healing time

	Bilateral Hoffmann frames $n=25$	Vidal-Adrey method $n=25$	Total material $n=50$
Duration of fixation with Hoffmann's device	24 weeks (13–62 weeks	24 weeks (11–74 weeks)	24 weeks
Roentgenological healing time	28 weeks (14–66 weeks)	27 weeks (11–74 weeks)	27 weeks

Table 3. Complications

	Bilateral Hoffman frames $n=25$	Vidal-Adrey method $n=25$	Total material $n=50$
Skin necrosis	5	2	7
Deep wound infection	0	1	1
Osteomyelitis	0	1	1
Pin infections	13	12	25
Nerve lesions	0	2	2

was the nerve lesion due to the external fixation. Two fractures, one in each group, were reoperated on with plate fixation and bone grafting because of delayed union. There was no definite pseudarthrosis and no leg amputation.

Residual deformities

A greater number of fractures healed with residual deformities in the group treated with the bilateral Hoffmann frames than in the group treated with the Vidal-Adrey method. In the former group 16 fractures healed with angular deformities exceeding 5 degrees, compared to 9 in the other group. The deformities were due in all cases to inadequate reposition. However, in most cases they were of little practical consequence, except one which needed a corrective osteotomy.

In 6 out of 7 patients with rotational deformities the tibia was rotated inwards. Average shortening was 4 mm in both groups.

Joint movement

Residual stiffness of the ankle and tarsal joints was found in a considerable number of patients as the movement was graded as fair or poor in approximately half of the injured legs in both groups. Residual stiffness of the knee joint was a minor problem (Table 4).

DISCUSSION

Our results confirm that Hoffmann's external fixation is a safe method of treating both bone and soft tissue in open and comminuted tibial fractures. In this material, consisting of 50 tibial fractures, there was only one case of

Table 4. Joint movement at the follow-up examination

	Bilateral Hoffmann frames $n=19$	Vidal-Adrey method $n=18$	Total material $n=37$
Knee joint:			
good	17	16	33
fair	1	2	3
poor	1	0	1
Ankle joint:			
good	9	9	18
fair	5	5	10
poor	5	4	9
Tarsus:			
good	12	9	21
fair	3	5	8
poor	4	4	8

osteomyelitis, no definite pseudarthrosis and no leg amputation.

The fractures of the two analysed groups were found to be comparable regarding soft tissue lesions. The group treated with bilateral Hoffmann frames contained relatively more combined diaphyseal and metaphyseal fractures. Furthermore, transverse and short oblique fractures were more frequent in this group. However, most of the fractures were comminuted, and since these were equally distributed between the two groups, we feel that the two groups were comparable with regard to fracture severity.

The considerably increased stability achieved with the introduction of the Vidal-Adrey modification of Hoffmann's device was believed to reduce the healing time and to give generally better results in external fixation of tibial fractures. However, in this study no difference was found concerning the healing time of fractures treated with the Vidal-Adrey method compared to fractures treated with the bilateral Hoffmann frames. There was a greater number of fractures with residual deformities in the group treated with bilateral Hoffmann frames because a less adequate reposition was obtained in these fractures. However, the deformities were in most cases so small that they were of little practical consequence.

It seems therefore that the Hoffmann apparatus, if duplicated as in our study, is stable enough in most cases. The considerably increased stability gained by the Vidal-Adrey method does not seem to reduce the length of the healing period or to give generally better treatment results. There was little difference between the two groups regarding complications of the treatment and residual joint stiffness.

The soft tissue lesions may have been the reason for the residual joint stiffness in the ankle and tarsal joints which was seen in approximately half of the patients of both groups. However, the possible role of the transfixing pins must not be neglected.

The long healing time, on average 6.5 months, reflects that Hoffmann's external fixation was used in comminuted fractures and/or fractures with severe soft tissue damage (Edwards 1965, Karlstrøm & Olerud 1977). After roentgenological healing, an additional period of 2 months, on average, was required until full weight-bearing without external support was achieved. This was partly due to concomitant lesions which hampered the restitution of the walking function.

The average healing time might perhaps have been reduced by permitting early weight-bearing in patients treated with the Vidal-Adrey method. Adrey stated in his biomechanical study (Adrey 1971) that the double frame mounting is sufficiently stable to permit full weight-bearing if there is contact between the bone ends. We have not permitted full weight-bearing in such cases until late in the healing course. It seems reasonable to assume that the small movements produced at the fracture site by full weight-bearing could stimulate the development of periosteal callus in the same way as suggested in functional fracture treatment by Sarmiento (1967), Dehne (1969) and Sarmiento et al. (1977).

At least in the treatment of comminuted fractures it seems unlikely that primary cortical healing will contribute significantly to healing of the fracture since this type of healing depends on an exact reduction in addition to rigid fixation (Perren 1979). However, if exact reduction is obtained, it seems that fixation with the double frame is rigid enough to achieve primary cortical healing, as seen in one case in our material and as pointed out by Lawyer & Lubbers (1980).

In the future use of the Vidal-Adrey modification with the double frame mounting, we will permit full weight-bearing at an earlier stage, if contact between the bone ends exists, to clarify whether early weight-bearing in such cases will accelerate the fracture healing.

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