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Hartshill rectangle: failure of spinal stabilisation in acute spinal cord injury

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Abstract A high rate of failure of the internal fixation of unstable spinal fractures in complete cord injured patients was noted in patients referred to the Salisbury Spinal Centre who had been stabilised with a Hartshill rectangle. This prompted a review of the operative notes, radiographs and clinical outcomes of all patients referred to the centre with a Hartshill rectangle in situ. All patients identified with a complete spinal cord injury and Hartshill rectangle were identified. Forty-three such patients referred from 13 different centres were found. Pre- and postoperative radiographs were assessed for fracture pattern and for spinal correction. Operative outcome in terms of pain and complications relating to surgery were identified. The most recent radiographs were assessed for signs of loss of reduc-

tion or stabilisation. Follow-up averaged 84 months (range 36–132 months). Of the 43 identified patients, 19 were found to have unsatisfactory stabilisation. Persistent pain, broken implants and worsening kyphosis were the main complications. The failure to use bone graft at the time of stabilisation was significantly ($P < 0.001$) related to risk of failure. The application and use of the Hartshill is not a technically challenging procedure; however, if the system is to be used, it must be used correctly. Failure to correctly apply the rectangle and to use bone graft will lead to an unacceptably high rate of failure.

Key words Hartshill rectangle · Stabilisation · Spinal cord injury · Thoracolumbar spine

Introduction

Posterior stabilisation of the spine using sublaminar wiring was first introduced by Luque [7], in 1984, who combined wires with two separate rods. The Hartshill system was introduced by Dove, in 1986; it combined the two Luque rods into a rectangle in an attempt to improve rotational stability [3]. The system has been reported to allow secure stabilisation of the spine irrespective of any neurological damage incurred in the primary injury. A high rate of failure was noted in patients with a complete spinal injury and a fracture stabilised with a Hartshill rectangle, stimulating us to analyse the operative detail of

these cases in order to identify any technical aspects of the procedures that may account for this discrepancy.

Materials and methods

The Duke of Cornwall Spinal Treatment Centre, Salisbury, admitted 644 patients with acute spinal cord damage between January 1984 and December 1995. Of these, 221 (34%) had undergone surgical stabilisation prior to admission. Forty-three patients had been stabilised with Hartshill rectangles and sublaminar wires. In all these cases, the spinal cord injury was complete. Stabilisation had been performed for pain and to facilitate patient care and transfer. The Hartshill system consists of rectangles of 5 or 6 mm thickness and sublaminar wires of various diameters. The aim of the study

Fig.1 A three-column L5 fracture stabilised with a well-contoured rectangle with bone graft. The appropriate-gauge wire has been used, but only one level above and one below the fracture have been wired. This case did well, with no complications specific to the fracture fixation

Fig.2 A mid-thoracic fracture dislocation reduced and stabilised with a rectangle that has a lordotic contouring. Early failure resulted, with breakage of the wires and painful instability

was to try to establish the cause of the high for incidence – 19/43 – of failure of fixation associated with the technique.

All patients admitted to the Duke of Cornwall Spinal Treatment Centre between January 1984 and December 1995 who had suffered complete cord injuries and had undergone spinal stabilisation at the referring centre with a Hartshill system were identified from the Centre's data base. Medical notes, radiographs and original operating notes were reviewed in each of the 43 patients studied.

Telephone interviews of patients were carried out to identify any symptoms or complications that were either ongoing or had occurred at any time since instrumentation.

Fractures were classified using Denis' three-column classification on anteroposterior and lateral radiographs [2].

We assessed radiologically, using both pre- and postoperative films, the adequacy of the spinal fixation with reference to the technique described by Dove [3–5].

The particular points looked for were:

1. The use of bone grafting at the time of stabilisation
2. Whether the appropriate number of levels had been included above and below the fracture (Fig. 1)
3. The appropriateness of the number, position and gauge of sublaminar wires used in association with the rectangle
4. The change in kyphotic angle pre- and post-fixation
5. Whether the contouring of the rectangle was appropriate for the spinal curvature

Failure to contour was defined as no contouring at all, i.e. the rectangle was flat or the contouring was the reverse of the normal spinal curvature (Fig. 2).

Failure of the fixation was defined as:

1. Radiological evidence of broken sublaminar wires
2. Painful kyphosis at the fracture site with loss of reduction

3. Neurological complications of fixation
4. Painful clinical (audible and palpable) instability
5. Pain of unknown cause persisting over 18 months
6. Infection of metal work

Results

Of the 43 patients, 36 were male, 7 were female. Ages ranged from 16 to 77 years, with an average age of 29 and a median age of 27. The distribution of injuries was 22 (51%) thoracic, 15 (35%) lumbar and 6 (14%) thoracolumbar.

Injuries ranged from single-level fractures to multiple-level fracture dislocations. Twenty-five patients presented with three-column burst fractures, 12 of which were at the L1 level. Fifteen patients had fracture dislocations, eight of which were thoracic, four thoracolumbar and three lumbar. Three patients had a two-column injury. All patients had complete neurological defects distal to their injuries.

Nineteen patients fulfilled the criteria for failure of fixation, including two cases of deep infection and two cases of persisting pain of uncertain aetiology. A list of complications is presented in Table 1.

In total, five patients required removal of the implants for persistent pain and clinical instability ($n = 2$) or deep infection ($n = 2$), with the remaining patient having undergone implant removal at the referring unit, for an un-

Table 1 Complications

	<i>n</i>
Wires broken and symptomatic	3
Wires broken but asymptomatic	2
Painful gibbus requiring revision	2
Neurological complication of wire placement	2
Painful prominent wires and rectangles	2
Infection	
Deep	2
Superficial	1
Painful movement at fracture site	2
Pain for over 18 months (cause unknown)	2
Removed prior to referral (cause unknown)	1
Total	19

documented indication, prior to their arrival at the Spinal Centre.

Bone graft was used in 19 of the patients stabilised with the Hartshill system. Of these 19 patients, only two had recorded complications: one patient had a broken wire and loss of reduction, the second a transient T1-2 neuralgia postoperatively, which was relieved by the removal of a misplaced sublaminar wire (Table 1).

The Chi-square value found from the association of lack of bone grafting with ensuing complications gave a value of 17.72, which gives a probability of $P < 0.001$, and the association therefore is highly significant. Failure to contour the rectangle peroperatively demonstrated similar rates of complications to the omission of bone graft ($P < 0.001$) (Fig. 2). Patients who had undergone bone grafting were more likely to have been fixed with a correctly contoured plate. Only 1 of the 15 contoured rectangles gave complications (pain and instability requiring revision), and this was in one of only three patients with a contoured plate who had not been grafted.

All the cases associated with fractured wires had incorrectly contoured rectangles (Fig. 2). As measured on pre- and postoperative lateral radiographs, the kyphotic angle was reduced in only 16 patients. It had remained the same in 23 patients, and the angle had in fact increased in one patient. No significant difference in complication rates was found between patients with a three-column burst fracture and those with a fracture dislocation.

No failures of fixation were found in the three cases of two-column injury. Numbers are insufficient to statistically comment.

No statistical relationship was found between level of injury and failure of fixation. There was no correlation between delay before surgery and failure of fixation.

Postoperative radiographs showed that a variety of wiring techniques had been used, including fine-gauge wire (14 cases), single loop, interosseous wiring (2 cases), and spinous process wiring (4 cases) (Fig. 3). Twenty-nine

Fig. 3 Spinous process wiring at the thoracolumbar junction. Narrow-gauge wires were used, which subsequently failed

of the 43 cases (67%) had been wired in a way that was consistent with Dove's description (two double loops of wire at each level, 18- or 20-G cold-worked stainless steel) [5]. In five cases the wires had fractured, four at the top of the fixation, one at the bottom of the rectangle.

Discussion and conclusion

Pedicle screw fixation of spinal fractures has superseded sublaminar wire procedures in many units. Biomechanical studies have suggested that such systems infer greater stability than the Hartshill system, most particularly in rotation [1, 8, 10]. Criticism of the ability of the Hartshill system to stabilise thoracolumbar fractures in seat-belt flexion/distraction fractures has led others to suggest the use of the Cotrel Dubousset instrumentation [10]. A recent comparison of the Hartshill rectangle and the AO internal spinal fixation system in burst three-column fractures again lent weight to the suggestion that to maintain the middle and anterior columns, a more rigid system was superior [1].

Our study does not attempt to compare the Hartshill system with other systems. However, no evidence of failure to maintain rotational stability was noted, and when correctly applied, successful stabilisation was achieved.

Failure to bone graft the fixation and the lack of contouring of the rectangle was found significantly to contribute to failure ($P < 0.001$). Rectangles applied with correct peroperative contouring were largely supplemented with bone graft. If grafted and contoured, no failure was found. This suggests that surgeons conversant with the

correct usage of the Hartshill system were aware of the need to bone graft and could expect good results.

The application and use of the Hartshill system as described by Dove and by Torrens [9] is not a technically challenging procedure. If the system is to be used, however, it must be used correctly. This study shows that where incorrect technique is used to apply the Hartshill rectangle, a high failure rate may be expected (19/43).

Our study has been unable to identify which pattern of spinal fracture is most appropriately stabilised with a Hartshill rectangle, as no difference in outcome was found between burst three-column injuries and those with a dislocation, nor even between two- and three-column injuries. A larger study may be needed to address this issue.

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