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Treatment of fractures of the thoracolumbar spine by combined anteroposterior fixation using the Harms method

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Abstract Forty-three patients with fractures of the thoracolumbar spine submitted to surgical treatment using the Harms method (dorsoventral operations) were studied prospectively with a follow-up of at least 12 months and evaluated on the basis of clinical and radiologic parameters and in relation to their professional activities. Thirty-five patients (81.3%) were males and eight (18.7%) females, ranging in age from 17 to 67 years (mean 34.08 ± 11.51 years). Seven patients (16.2%) presented fractures of more than one vertebra, and associated lesions were present in 15 patients (34.8%). Monosegmental fixation was performed in 7 patients (16.3%), bisegmental fixation in 29 (67.4%), and trisegmental fixation in 7 (16.3%). No patient was submitted to any type of external immobilization during the postoperative period and all patients were allowed to sit up in bed and to walk as soon as their clinical conditions permitted. Thirty-nine patients were followed up for a period ranging from 12 to 36 months (mean 16.58 ± 6.83 months). Four patients died during the postoperative period (three of pulmonary embolism and one of septicemia). Forty-two patients sat up in bed between the 2nd and 6th postoperative day, and those who did not present a disabling lesion (Frankel D or E) or other associated lesions walked between the 4th and 10th postoperative day (mean 6.14 ± 6.06 days). The neurological signs and symptoms improved in 16 patients (37.3%), were unchanged in 26 (60.4%), and worsened in 1 (2.3%). Twenty-three patients (87.5%) who had no neurological damage (Frankel E) returned to their professional activities after respective periods of disability of 1 month (three patients), 2 months (four patients), 3 months (one patient), 4 months (seven patients), 5–7 months (five patients), 8–12 months (one patient), and more than 12 months (three patients). The ability to work of the 24 patients without neurological damage was 100% in 21, 50% in 2, and zero in 1. The ability to walk of this group of patients was 1–5 km for 4 and more than 5 km for the remaining 20 patients. The complications observed were death (four patients; three cases of pulmonary embolism and one case of septicemia), infection (two patients), Stevens-Johnson syndrome (one patient), and meningitis (one patient). The mean kyphosis of the fractured segment was 22.17° ± 10.97° preoperatively, 8.55° ± 6.9° postoperatively, and 10.30° ± 8.84° on the occasion of late evaluation. No loss of correction occurred in 28 patients (71.8%), a 5° loss was observed in 3 patients (7.6%), a 6° loss in 3 (7.6%), a 7° loss in 3 (7.6%), and a loss of more than 10° in 2 (5.2%).

Key words Thoracolumbar fractures · Spinal fusion · Dorsoventral fixation · Spinal fixation · Harms technique

Introduction

Over the last decade, surgical treatment of the thoracolumbar spine has greatly developed and has undergone profound changes as a consequence of refining its objectives. The preservation of intact vertebral segments, improvement of the neurological status, and the abandonment of external immobilization were the major objectives proposed for the modern treatment of these fractures [16, 30]. Many new implants and systems of vertebral fixation have been developed to fulfill the above objectives [2, 8, 9].

The surgical treatment of these fractures is intimately related to the instability of the injured vertebral segment, and the major objective of the method described by Harms [14, 16] for the treatment of these fractures is the permanent re-establishment of the stability of the vertebral segment, in addition to the objectives mentioned above.

Biomechanical studies of the spine have demonstrated that in the upright position approximately 80–90% of the forces of axial compression are absorbed by the anterior part of the spine, while the posterior articular facets absorb the remaining 10–20%. The muscles that hold the trunk erect act as tension bands, and their action stabilizes the passive distribution of the pressures on the anterior and posterior portions of the spine [17, 30]. These biomechanical observations guide the principles of the treatment proposed by Harms, who recommends the reconstruction of the anterior part of the spine, which is responsible for supporting the anterior weight, with a corticocancellous bone graft associated with anterior instrumentation through the lateral surface of the vertebral bodies, and posterior transpedicular instrumentation in which the implants act as tension bands [14, 16]. Restoration of the anterior spine, which is responsible for weight support, and of the posterior spine, by means of implants acting as tension bands, corresponds to the principles of biomechanical correction involved in the method [15, 17, 27].

The spine is approached by the anterior and posterior routes, decompression of the vertebral canal is performed when indicated, and only the vertebrae of the vertebral segment involved are instrumented and submitted to arthrodesis, with fixation and arthrodesis of only one vertebral segment being possible on occasion [14, 16]. Due to the stability provided by the method of fixation, it is not necessary to use external immobilization during the postoperative period [33]. The system of vertebral fixation used in this method consists of screws to which threaded bars measuring 4 mm in diameter are coupled. The screws may have a fixed head (USIS) or a mobile head (MOSS) [17, 27, 29].

The objective of the present study was to analyze prospectively the results of treatment of the thoracolumbar spine by the Harms method over a period of at least 12 months, considering clinical and radiologic parameters, as well as parameters related to the professional activities of the patients for evaluation of the results.

Patients and methods

A prospective study was conducted on 43 patients (35 males, 81.3%, and 8 females, 18.7%) with fractures of the thoracic or lumbar spine surgically treated by the Harms method between March 1990 and March 1993. Patient age ranged from 17 to 67 years (mean 34.08 ± 11.51 years).

The cause of fracture was a fall from a high level in 20 patients (46.5%), an automobile accident in 19 (44.2%), and direct traumatic injury in 4 (9.3%).

The vertebrae most often involved were L1 (15 patients; 34.8%) and L2 and T12 (8 patients; 18.6%). T9 and L4 were involved in two patients, T10 in one patient, and T11 in three patients. Six patients (16.2%) had fractures of more than one vertebra (T8-T9 in two patients, T10-T11 in one patient, and T11-T12 and T12-L1 in three).

According to the classification of Denis [7], 2 patients had a type D compression fracture and 1 patient had a type B compression fracture; 15 had a type A burst fracture, 4 a type B burst fracture, 1 a type D burst fracture, and 2 a type E burst fracture. Only one patient presented a fracture of the “seat belt” type; fracture-luxations of the flexion-rotation type were observed in 16 patients and a fracture of the shearing-luxation type was observed in 1. According to the classification of Magerl et al. [19], 12 patients had a group A fracture, 3 had group B fractures, and 28 group C fractures.

The patients were evaluated neurologically according to the classification proposed by Frankel et al. [12]; 10 patients had group A injury, 7 group B injury, 2 group C injury, 5 group D injury, and 18 group E injury.

The following associated injuries were observed in 15 patients (34.8%): fracture of the femur (2 patients), abdominal traumatic injury (4 patients), fracture of the pelvis (2 patients), bilateral fracture of the heel (1 patient), fracture of the forearm (1 patient), fracture of the elbow (1 patient), fracture of the ankle (1 patient), injury to the brachial plexus (1 patient), fracture of the mandible (1 patient), fracture of the tibia (1 patient), skull and brain injuries (1 patient), unilateral fracture of the heel (2 patients), fracture of costal arches (1 patient), and shock lung (1 patient). Some of these patients had more than one associated injury.

The interval between the two operations ranged from 0 to 15 days in 35 patients (mean 5.7 ± 4.1 days), 9 of whom were submitted to the anterior and posterior approach during the same surgical act. When this was not possible, the preferential interval between the two operations was 7 days, but this interval was increased in the presence of complications or other clinical limitations, as was the case for seven patients for whom the interval between operations was more than 15 days.

The indication for surgical treatment of the fractures was conditioned by the presence of instability of the vertebral segment or by neurological deficit, and the USIS system (Universal Spine Instrumentation System, Ulrich) was used in all cases for anterior and posterior vertebral fixation. A corticocancellous bone graft obtained from the iliac bone was used in 41 patients (95.3%) and a graft from the fibula was used in 2 patients (4.7%). Arthrodesis was monosegmental in 7 patients (16.3%), bisegmental in 29 (67.4%), and trisegmental in 7 (16.3%). Corporectomy for decompression of the vertebral canal was performed in six patients (13.9%) (Figs. 1, 2). No type of external immobilization was used during the postoperative period in any of the patients, who were allowed to sit in bed and to walk as soon as their clinical condition permitted.

The patients were evaluated on the basis of clinical and radiologic criteria during the preoperative, immediate postoperative,

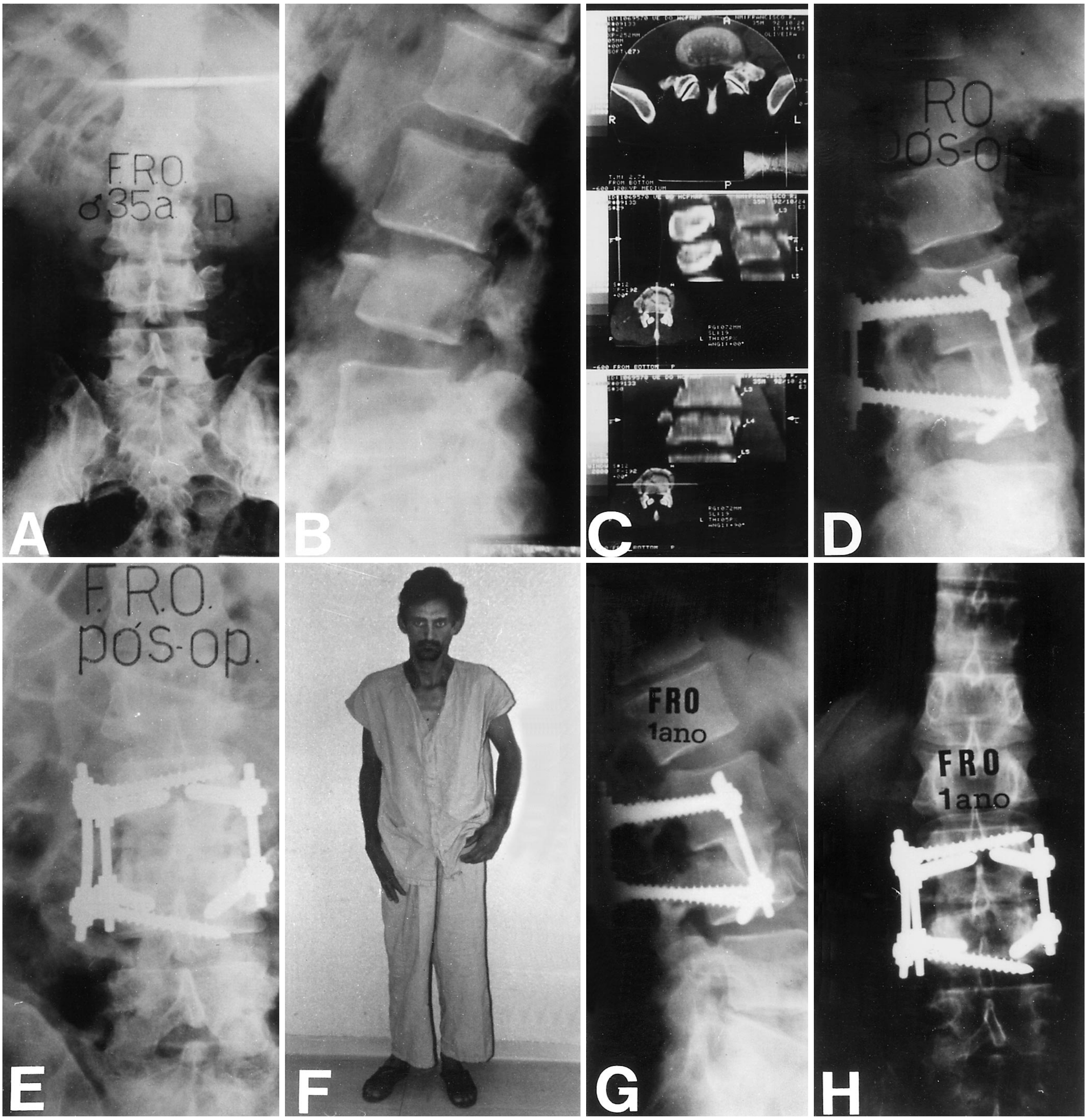

Fig. 1 F.R.O., a 35-year-old man with an L4 Frankel D fracture. **A, B** Preoperative AP and profile radiographs. **C** Preoperative CT sans. **D, E** Postoperative profile and AP radiographs after monosegmental fixation. Observe the cortical-spongy graft between L3 and L4. **F** Clinical aspect of the patient on the 4th postoperative day. **G, H** Radiographic control 1 year after surgery

and late postoperative periods, with a minimum postoperative follow-up of 12 months. Clinical evaluation considered improvement of the initial signs and symptoms, presence of pain, evolution of the neurological status according to the classification of Frankel et al. [12], and the complications related to the pathology or to treatment. The aspects considered during the immediate postoperative period were the ability to sit up in bed, the beginning of rehabilitation, and walking.

On the occasion of the late clinical evaluation, in addition to the previous parameters, the aspects considered were return to work, duration of the inability to work, the percentage of ability to work, the ability to walk, and the subjective opinion of the physician and patients about the final result of treatment. The objective of radiologic evaluation was to study the morphology of the fractures for classification, the kyphosis of the fractured segment (angle between the upper and lower vertebral plates of the vertebrae adjacent to the frac-

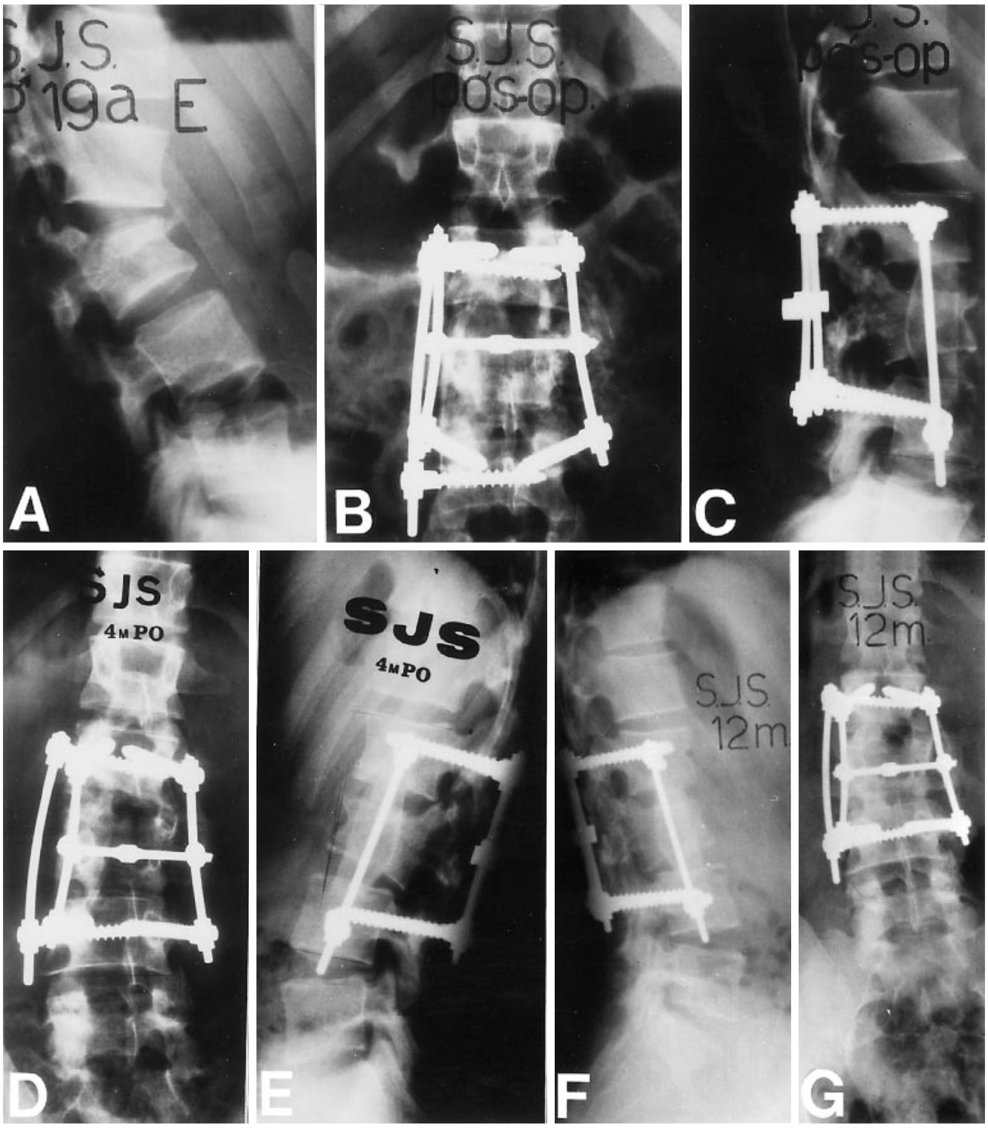

Fig. 2 S.J.S., a 19-year-old man with an L3 Frankel E fracture. **A** Preoperative profile radiograph. **B, C** Postoperative AP and profile radiographs after bisegmental L2–L4 fixation. **D, E** AP and profile radiographs 4 months after surgery. Observe the bending of the bar of the fixation system on the frontal plane. **F, G** Radiographic control 12 months after surgery

ture) during the preoperative, immediate postoperative and late postoperative periods, as well as the maintenance and loss of correction, integration of the bone graft, deformity, and loosening or breaking of the components of the fixation system.

Results

Of the 43 patients operated upon, 39 were followed up for at least 12 months and up to a maximum of 36 months (mean 16.58 ± 6.83 months). Four patients died during the postoperative period (three of pulmonary embolism and one of septicemia), all of them presenting severe neurological damage (Frankel A).

Forty-two of the patients were able to sit up in bed between the 2nd and 6th postoperative day (mean 4.47 ± 5.6 days); one patient with meningitis did so only after 15 days.

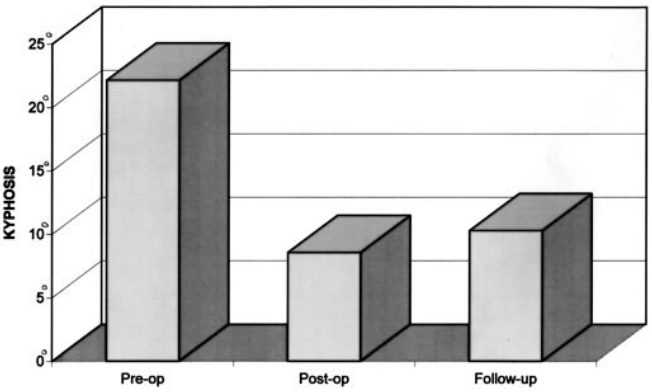

Fig. 3 Evolution of mean kyphosis of the damaged vertebral segment during the preoperative, immediate postoperative, and late postoperative periods

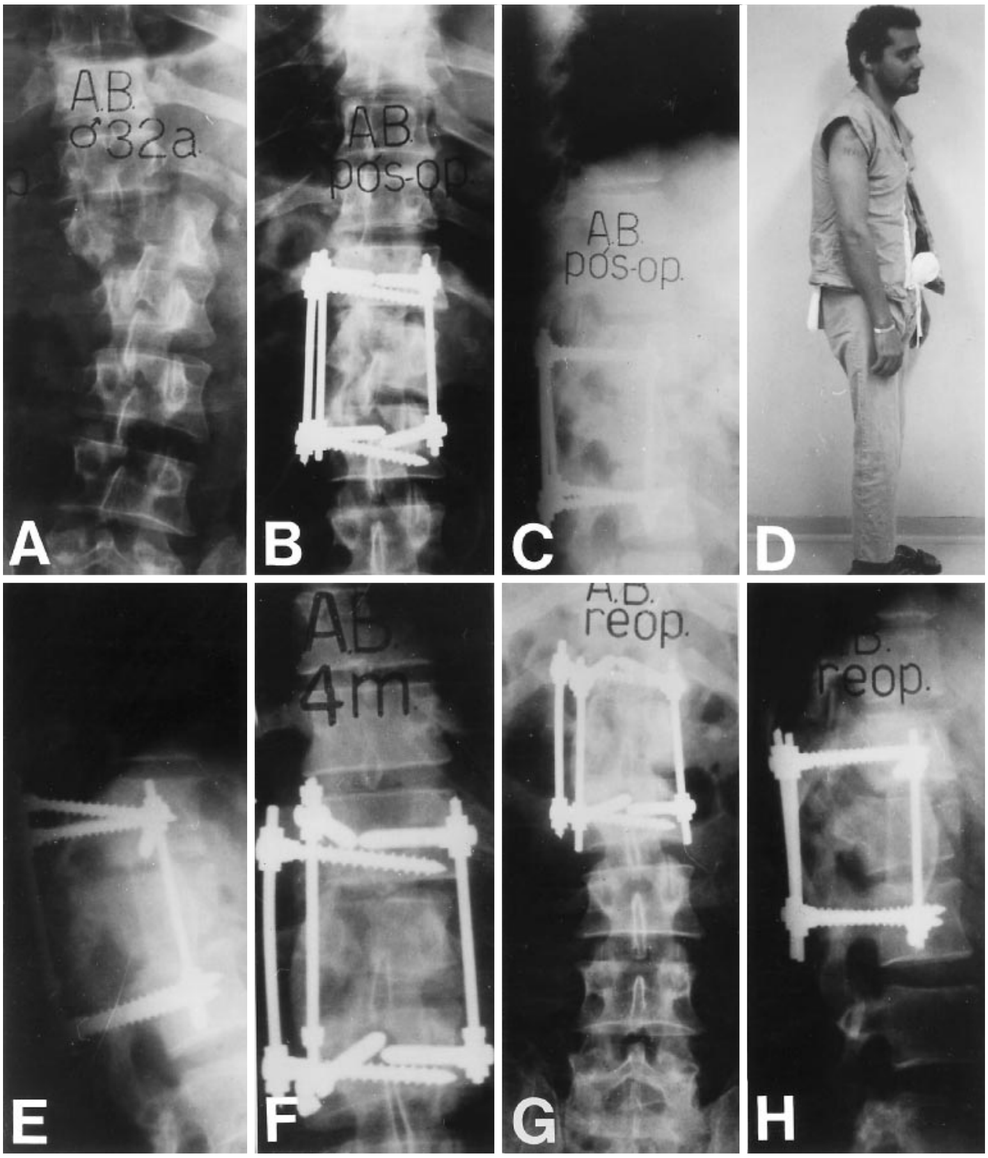

Fig. 4 A.B., a 32-year-old man with an L1 Frankel B fracture. **A** Preoperative radiograph. **B, C** Radiographs taken after combined fixation of the lesion and corporectomy. **D** Clinical aspect of the patient 4 months after surgery. **E, F** Radiographs taken 4 months after surgery. Note the loosening of the posterior implant and the loss of correction. **G, H** Radiographs taken after debridement and repositioning of the posterior implants

The patients with no disabling neurological injuries (Frankel D or E) or other limitations related to their general condition or associated injuries (21 patients) walked between the 4th and 10th postoperative day (mean 6.14 ± 5.06 days). The patients who had no neurological damage (Frankel E) or associated injuries (15 patients) were able to walk between the 4th and 7th postoperative day (mean 5.53 ± 1.5 days).

The neurological signs and symptoms improved in 16 patients (37.3%), were unchanged in 26 (60.4%) and worsened in 1 patient (2.3%). Upon late evaluation, 3 patients were assigned to group A, 3 to group B, 3 to group D, and 24 to group E of the Frankel scale.

The worsening of the neurological status that occurred in one patient was due to the migration of a large fragment of the posterior wall of the vertebral body to the inner part of the vertebral canal during reduction and posterior fixation of the lesion. Despite immediate corporectomy after the detection of the neurological worsening, the initial neurological status of the patient (Frankel C) was not reestablished and his status on the occasion of late evaluation was Frankel B.

The complications observed were death of four patients (three of pulmonary embolism and one of septicemia), profound infection (two patients), superficial infection (two patients), Stevens-Johnson syndrome (one patient), and meningitis (one patient). Upon late evaluation, all patients reported improvement of the early status, 38 (97.4%) had no pain and 1 (2.6%) complained of mild pain when flexing his spine.

Twenty-two of the 39 patients in the group (56.4%) returned to their professional activities. When considering the neurological status observed upon late evaluation, only one of the three patients with Frankel A injury returned to work. Of the 3 patients with Frankel B injury, the 6 patients with Frankel C injury, and the 3 patients with Frankel D injury, none returned to their professional activities. Of the 24 patients with a Frankel E neurological status, 21 (87.5%) returned to work. The three type E patients who did not return to work were prevented by infection with the presence of a fistula (1 patient), alcoholism (1 patient), and damage to the brachial plexus (1 patient).

The duration of working disability was more than 12 months in the patient in group A who returned to work. In group E patients, the duration of working disability was 1 month (three patients), 2 months (four patients), 3 months (one patient), 4 months (seven patients), 5–7 months (five patients), 8–12 months (one patient), and more than 12 months (three patients). For the three patients in group A, the ability to work was 50% in one and zero in the other two. The three patients in group B and six patients in group C were unable to return to work. In the three patients in group D, the ability to work was 50% in 1 and zero in the other two. In the 24 patients in group E, the ability to work was 100% in 21, 50% in 2 and zero in 1.

The ability to walk for the three patients in group D was 100–1000 ms, 1–5 km, and more than 5 km, respectively. In the 24 patients in group E the ability to walk was 1–5 km in 4 and more than 5 km in 20. The patients in groups A, B, and C were unable to walk.

One patient complained of mild pain upon palpation of the anterior surgical scar, but no other intra- or postoperative complications related to this route of approach were observed.

Radiographic analysis of the fractured segment showed a mean kyphosis of 22.17° ± 10.97° during the preoperative period, 8.55° ± 6.95° during the immediate postoperative period, and 10.30° ± 8.84° on the occasion of late evaluation (Fig. 3). Twenty-eight patients (71.8%) presented no loss of correction, three (7.6%) presented a 5° loss, three (7.6%) a 6° loss, three (7.6%) a 7° loss, and two (5.2%) a loss of 10° or more (Fig. 3). Incorrect indication of monosegmental arthrodesis and infection were the causes of loss of correction in the patients with a loss of 10° or more (Fig. 4).

Radiographic evaluation showed satisfactory integration of the bone graft in all patients, with no type of problem or complication.

The alterations observed in the implants were bending of the rod for the fixation system in four patients (Fig. 2) and loosening of the nut of one of the screws in one patient who presented infection (Fig. 4).

Discussion

The principles of the treatment method developed by Harms are based on biomechanical and functional concepts concerning the spine. The concern Harms showed for staying true to biomechanical principles was already evident at the time when pedicular fixations were still unavailable, when the author reconstructed the anterior portion of the spine in combination with posterior instrumentation with Harrington rods [30].

Short vertebral arthrodesis became possible with the development of pedicular fixation, which permanently reestablishes the stability of the damaged vertebral segment while at the same time satisfying the other requirements of modern spinal surgery [14–16]. The importance of an anterior vertebral graft in short arthrodeses has been recently confirmed in experimental studies [20, 24, 34] as well as by the unsatisfactory results obtained for patients not submitted to anterior reconstruction of the spine [5, 28, 32]. Whitecloud and Shaw [32], Carl et al. [5], and Stephens et al. [28] reported a loss of correction, increased kyphosis, and implant breaks at the time of late evaluation in patients submitted only to posterior pedicular fixation. Although most patients presented a satisfactory clinical evolution, the authors believed that an anterior graft might have prevented the faults observed [20].

The distribution of fracture location in the present patient series, as well as the predominance of these lesions in males, are in accordance with available epidemiologic data [19]. A higher percentage of type C fractures was observed according to the classification of Magerl et al. [19], indicating that these fractures were particularly serious as far as stability and the risk of progressive deformity were concerned. Fractures involving multiple adjacent vertebral segments were observed in seven patients (16.2%) and, in contrast to previous reports [25], only one of these patients had suffered multiple injuries.

Clinical evaluation showed highly satisfactory results with respect to the parameters studied if we consider the complexity of the lesions and the presence of associated lesions in 15 patients (34.8%). The mechanical stability provided by the anterior and posterior fixation of the fractured vertebral segment obviates the need for external immobilization during the postoperative period, allowing great freedom of movement for the patients and contributing in a significant manner to functional rehabilitation and to an early return to daily activities. In a biomechanical study, Wöersdörfer et al. [33] observed the superiority of this modality of vertebral fixation compared to conventional systems of vertebral fixation, and Maiman et al. [20] emphasized the importance of posterior fixation and the value of short segment pedicle fixation in association with anterior vertebral surgery.

In the present study, the return of patients to their professional activities reflected the value of the method used, with a high percentage of patients without neurological damage returning to work. A large number of these patients were fully able to work, and many of them were involved in activities that required great physical effort. The duration of the inability to work should also be emphasized, with a relatively early return to work among patients whose professional activities did not require considerable physical effort.

The fact that the group of patients with neurological damage did not return to work reflects the shortcomings of our public health system in socioeconomic terms. Although these patients were ready for an early start of rehabilitation, their professional reintegration did not occur, a frustrating fact when we consider the rates reached by patients who do have access to programs of professional rehabilitation [4].

The postoperative complications observed did not reach the alarming levels reported by Mumford et al. [22], who cited a 54% rate of complications among surgically treated patients, and the anterior approach did not cause an increase in the percentage of complications during treatment. The occurrence of meningitis as a complication of spinal surgery, observed in one of our patients, although rare with an incidence of about 0.18% [31], has also been reported by others [3, 21].

Although postoperative maintenance of correction was observed in 71.8% of our patients, a small loss of correction ranging from 5° to 7° was observed in some of them; there was, in addition, a greater loss due to incorrect monosegmental fixation in one patient and due to infection in another. The explanation of these smaller losses of correction may be the penetration of the tricortical bone graft into the adjacent vertebral bodies, as observed by Maiman et al. [20] in a biomechanical assay with vertebrae. Bending of the rod of the fixation system, which was observed in a few patients, may also have been related to penetration of the bone graft into the vertebral body, or even to an excessively lateral positioning of the bone graft. The use of a titanium cage may prevent this penetration of the bone graft into the vertebral body. Hollowell et al. [18] observed that preservation of the endplate did not significantly increase the resistance to graft subsidence and the titanium cage construct provided the greatest resistance to axial load. The effect of decompression of the vertebral canal on the recovery from neurological deficits continues to be a controversial subject, although clinical and experimental studies have suggested it has a beneficial effect in patients with incomplete neurological damage [13, 26]. It is difficult to establish a threshold of canal compromise ratio above which surgical decompression is needed to prevent late neurological deficits in the thoracolumbar burst fracture [11, 23].

In our practice we perform direct canal decompression using an anterior approach and corporectomy, or indirect decompression by ligamentotaxis (reduction of retropulsed fragments by an intact posterior longitudinal ligament). We observed improved neurological signs and symptoms in 37.3% of our patients, but the size of our sample does not permit us to draw a conclusion about the real role of canal decompression in neurological recovery.

The treatment of fractures of the thoracolumbar spine continues to be controversial and no consensus exists about the ideal method [22]. This lack of consensus is directly related to the different parameters used to indicate the type of treatment, to divergences about the objectives to be reached, and also to the criteria for its evaluation. As an example, we may cite loss of correction and break of implants, considered to be unacceptable results by some investigators [17, 20, 30], but not by others because they are not correlated with pain or functional disability [1, 6].

We believe that the establishment of clear and well-defined objectives for the treatment of these lesions, together with the choice of a treatment modality based on well-established biomechanical principles, is fundamental for obtaining more satisfactory results. It is also important to evaluate the results on a long-term basis to find out whether our objectives are being reached and what we can do to improve our results. On the basis of this philosophy of treatment, we have used the method recommended by Harms, which satisfies the current requirements for treatment of these fractures while also satisfying the biomechanical needs of the injured vertebral segment. The early start of rehabilitation and the early ability to walk and to return to work, together with the small area of arthrodesis and the absence of postoperative immobilization, are all advantages of using this method for the surgical treatment of fractures of the thoracolumbar spine, as is the possibility of obtaining reduction and correction of possible angular shifts during the surgical act. However, we cannot overlook the relative disadvantage of the anterior approach as an additional procedure for those patients who do not need canal decompression, although we did not observe complications after its routine use. In patients who do require decompression, anterior surgery results in a more complete and reliable decompression of the canal [10], in addition to presenting the biomechanical advantages mentioned earlier.

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