TREATMENT OF TRAUMATIC DISLOCATIONS OF THE CERVICAL SPINE THROUGH ANTERIOR APPROACH

HELTON L. A. DEFINO[1], FÁBIO GOMES FIGUEIRA[2], LAURO SCHLEDORN DE CAMARGO[2], FABIANO RICARDO DE TAVARES CANTO[3]

SUMMARY

Twenty patients presenting with single-or bi-faceted traumatic dislocation of the cervical spine treated by means of arthrodesis and anterior fixation have been studied. Patients were assessed by clinical, X-ray, and functional parameters. The patients were followed up during a period ranging from 1 to 14 years. Union of the arthrodesis, as evidenced by X-ray, was noticed in all patients, with one patient presenting with late loosening of one of the screws. Angulations at sagittal plane of the injured vertebral segment showed a change preoperatively, with reduction being achieved at the early postoperative period and maintenance after one year post-surgically. The clinical and functional assessment according to SF-36 and to Denis' pain and effort scale showed good clinical results with the major postoperative complaints being resultant from the neurological injury degree. The hematoma observed on surgical wound, which required surgical drainage was the only complication reported in a patient. The approach employing arthrodesis and anterior fixation for treating single- or bi-faceted traumatic dislocations of the cervical spine showed good clinical, X-ray, and functional outcomes, as well as a small complications rate, thus justifying our preference for this method when treating these kinds of cervical spine injury.

Keywords: *Spinal injuries; Spinal cord injuries; Arthrodesis; Cervical vertebrae.*

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INTRODUCTION

Traumatic injuries of the cervical spine present a broad injury spectrum and its specific types must be considered for outcomes analysis. This was the reason for including only single or double-faceted dislocations in the present study. Single or double-faceted of the cervical spine are regarded as injuries belonging to type B or C, according to the classification recommended by the AO group, which is based on the morphopathology of the injury(1) (Figure 1). Type-B injuries are produced by cervical spine's distraction mechanism, with three subgroups: B1- posterior elements injuries, B2- posterior elements injuries combined with vertebral body fracture, and; B3- injury resulting from hyperextension. Type-C injuries are produced by rotation mechanism and are subdivided into three subgroups: C1- unilateral faceted fracture-dislocation, C2- unilateral faceted dislocation, and; C3- fracture-separation of the joint dull (Figure 1). According to the classification employed here, single or double-faceted dislocations of the cervical spine would correspond to type-B1 injuries (double-faceted dislocation), C1 (single-faceted fracture-dislocation) or C2 (unilateral faceted dislocation). Those injuries are characterized by intervertebral disc and posterior ligaments injuries.

This kind of injury has no healing potential and the recovery of the injured vertebral segment stability cannot be achieved by means of external immobilization, potentially causing chronic cervical pain, progressive deformity and neurological injury when no appropriate treatment is provided [2-4]. Surgical treatment by means of reduction, arthrodesis and fixation of injured vertebral segment has been recommended as the method of choice for treating these injuries. However, no consensus exists about the best approach, with preferences divided into anterior or posterior approach [5] .

Our therapeutic approach for the surgical treatment of traumatic single or double-faceted traumatic injuries of the cervical spine has been performed by means of arthrodesis and anterior fixation, and the objective of this study is to present the outcomes achieved in our patient series consecutively treated by using this method.

MATERIALS AND METHODS

Twenty patients with single or double-faceted traumatic dislocation of the cervical spine and submitted to surgical treatment by means of anterior fixation and arthrodesis were retrospectively studied.

Eighteen patients (90 %) were males and two (10 %) females, ages ranging from 11 to 58 (average 35.85 ± 12.3 years). The etiology of trauma was car accident (9 patients, 45%), shallow dive (5 patients, 25%) , high falls (4 patients, 20%) and falls from horses (2 patients, 10 %). The injury happened on C3-C4 segment of 1 patient (5 %), C4-C5 of 9 patients (45 %), C5-C6 of 7 patients (35 %) and on C6-C7 of 3 patients (15 %). According to the scale by Frankel et al[6-8], 5 patients (25 %) were class A, 2 (10 %) class B, 2 (10 %) class D and 11 (55 %) as class E. Injuries were B1-type (10 patients), C1 (8 patients) and C2 (2 patients), according to the classification recommended by AO group (Figure 2).

Surgical treatment recommendation was related to the instability inherent to single or double-faceted traumatic dislocations of the cervical spine, and also to the neurological deficit in some patients. Preoperative traction was employed in 11 patients, achieving a preoperative reduction in 8 out of 11 patients. In 3 patients, reduction was not achieved by means of traction, requiring open intraoperative reduction. In 9 patients else, preoperative traction was not performed, and the reduction was achieved intraoperatively after discectomy of the injured vertebral segment.

Surgical treatment was performed by means of the anterior approach, using a cross-sectional incision on the right side of cervical spine at injured segment height. Fixation and monosegmentar arthrodesis were performed with H-type plates (14 Morscher's plates

Study conducted at the Department of Biomechanics, Medicine and Locomotive Apparatus Rehabilitation, Medical College, Ribeirão Preto – USP, Spine Surgery

Correspondences to: Av. Dos Bandeirantes 3900, Campus Universitário, Monte Alegre, Rib. Preto – SP; CEP: 14048-900; e-mail: hladefin@fmrp.usp.br

1. Associate PhD Professor, Department of Biomechanics, Medicine and Locomotive Apparatus Rehabilitation, Medical College, Ribeirão Preto – USP.
2. Orthopaedic and Traumatology Doctor; Resident Doctor, Department of Biomechanics, Medicine and Locomotive Apparatus Rehabilitation, Medical College, Ribeirão Preto – USP.
3. Post-graduation student, Department of Biomechanics, Medicine and Locomotive Apparatus Rehabilitation, Medical College, Ribeirão Preto – USP.

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and 6 Orozco's plates), and a cortical-spongy graft was removed from the iliac. The patients wore cervical collars for a period of 12 weeks after surgery. Gait and rehabilitation were started according to patient's overall status, neurological injury and pain. Surgery was performed at least 7m days after injury in 17 patients, and between 25-30 days in three patients due to combined injuries and co-morbidities.

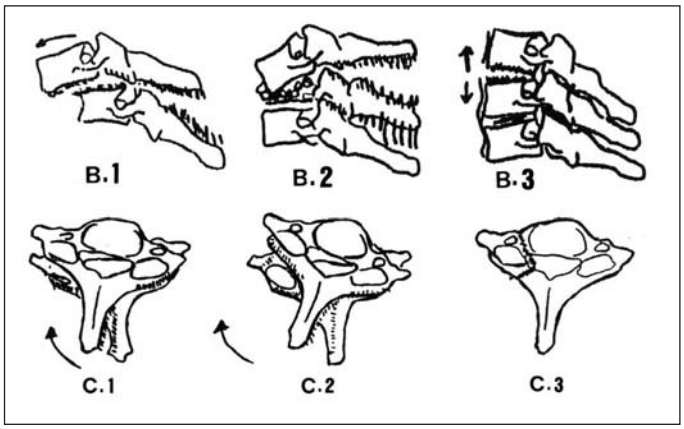

Figure 1 - *B- or C-type injury and its correspondent sub kinds, according to the classification recommended by the AO group.*

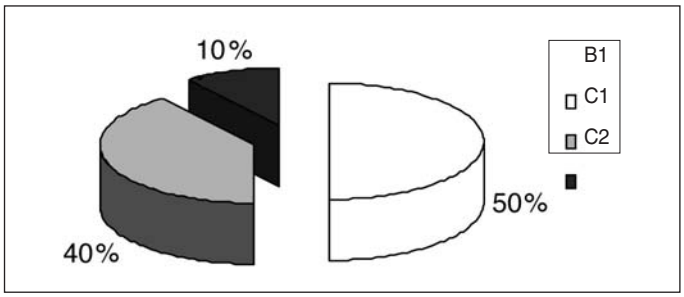

Figure 2 - *Distribution of traumatic injuries according to the classification by the AO group.*

Patients were assessed by means of clinical, X-ray and functional parameters preoperatively, at early postoperative time (EPO) and late postoperative time (LPO). Clinical analysis of the patients was performed by means of residual pain, neurological picture (according to the scale by Frankel et al.), and complications assessment, while functional assessment was performed by means of protocols SF-36[9,10] and Denis' pain and work scale[11] (Tables 1 and 2).

The X-ray assessment was performed based on simple X-ray images of the cervical spine, comparing preoperative, early postoperative (EPO) and one-year postoperatively (LPO) images. The injured vertebral segment angle at sagittal plane was measured (Figure 3), and the reduction maintenance or loss, anterior arthrodesis union, the presence of posterior ankylosis, and the loosening or change of implants were checked. The X-ray-related criteria used for determining arthrodesis union were: visualization of bone trabecules crossovers between arthrodesis area's surfaces, and the absence of radioluminescence.

A statistical analysis was performed for comparing pre and postoperative (early and late) values of the vertebral segment angle at sagittal plane, using non-parametric methods for results analysis. We adopted $p \leq 0.05$ as the significance level. The Friedman's test was performed and, as a significant difference occurred, we performed the Wilcoxon's test for paired samples with Bonferroni's correction intending to detect the significant differences.

Table 1
Denis' Pain Scale

P1	No pain.
P2	Occasional mild pain, not requiring medication.
P3	Moderate pain; occasional use of medication, not precluding the performance of professional or daily activities.
P4	Moderate to severe pain; occasional job absence, significant changes on daily activities.
P5	Continuous severe pain; use of chronic medications for pain.

Table 1 - *Denis' Pain Scale.*

Table 2
Denis' Work Scale

W1	Return to previous work (heavy duty) or physical activities.
W2	Able to return to previous activity (sedentary) or return to heavy work with restraints.
W3	Unable to return to previous work, but works in another function.
W4	Unable to return to work full-time.
W5	Unable to work.

Table 2 – Denis' Work Scale.

RESULTS

The patients were followed up for a period that ranged from 1 to 14 years (average 3.27 ± 2.79 years). Three patients presenting

Figure 3 - *X-ray image at lateral plane showing a cervical spine, representing the method used for measuring kyphosis or lordosis angle for the injured vertebral segment.*

A-type neurological injury according to Frankel's scale deceased due to clinical complications. In these three patients, functional evaluation protocols (SF-36 and Denis' pain and work scale) could not be applied, and are not included in the results, but clinical and X-ray follow-up was documented on medical files, therefore they were included in the results.

Complications found during postoperative period were postoperative hematoma (1 patient) and late loosening of one of the plate screws (1 patient), requiring surgical intervention in both cases for hematoma drainage and implants removal.

According to Frankel's scale, 3 patients showed an improved neurological picture during follow-up (B to D; B to C; D to E). Neurological picture remained the same in 17 patients, with no neurological damage after surgery.

The subjective evaluation according to Denis' pain scale showed that cases classified as Frankel E (no neurological deficit) did not present significant pain at late postoperative period, and the cases

with some degree of neurological deficit (Frankel A to D) maintained some residual pain, with one patient presenting with a continuous pain (Figure 4). According to the work scale, we found that 11 of the 12 patients without neurological deficit (Frankel E) went back to their usual previous activities, 9 of them in heavy jobs, 2 in light job, and only one had to switch to another kind of professional activity. No patient with neurological deficit returned to their previous usual activities, but 2 of the 5 patients assessed are able to keep some kind of function (Figure 5).

The functional assessment according to the SF-36 was divided into two groups, with and without neurological deficit (Frankel A to D and Frankel E, respectively). Considering that the maximum score is 100%, we found scores of 100% in Frankel E cases for physical function, 100% for functional restraint, 99.58% for restraint due to emotional problems, 84% for energy/ fatigue, 81% for emotional welfare, 79.9% for social function, 97% for pain, and 92.5% for overall health status. But, in Frankel A to D group, we found 28% for physical function, 25% for functional restraint, 49.6% for restraints due to emotional problems, 43% for energy/ fatigue, 45.2% for emotional welfare, 39.2% for social function, 41% for pain, and 45.2% for overall health status (Figure 6).

At postoperative period, we report physiological lordosis loss in all patients with values ranging from 5 to 45 degrees of kyphosis (average 15.35 ± 8.81 degrees of kyphosis). At the early postoperative period, the lordosis of the injured vertebral segment was restored, with values ranging from 1 to 25 degrees of lordosis (average 9.05 ± 6.08 degrees). At late evaluation, the lordosis of the injured segment ranged from 1 to 20 degrees (average 7.55 ± 5.09 degrees), with a lower than 5 degrees of reported loss compared to early postoperative values in 19 patients (95%) and 10 degrees of loss in 1 patient (5%) (Figure 7). We noticed that the injured segment angle value loss occurred in the first six months after surgery.

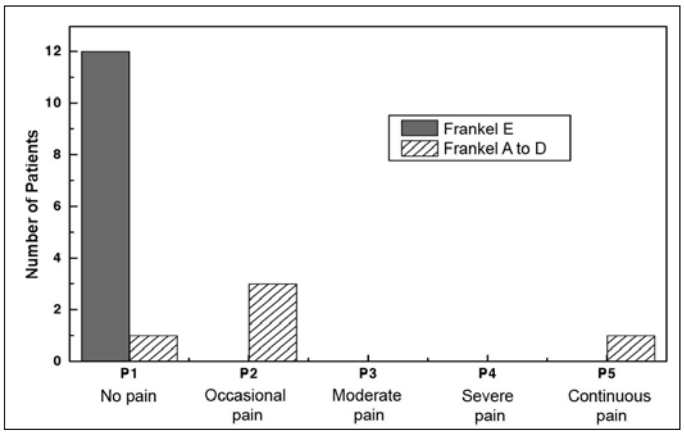

Figure 4 - *Results of the late evaluation, according to Denis' pain scale, comparing cases with and without neurological deficit.*

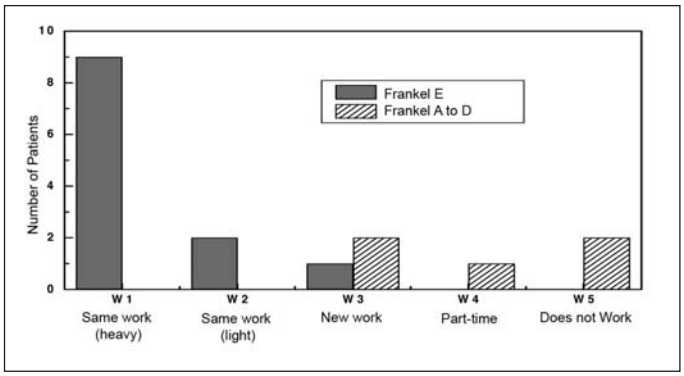

Figure 5 - *Results of the late evaluation, according to Denis' Work Scale, comparing cases taking neurological deficit into account.*

The Friedman's test suggested significant differences between pre- and postoperative assessments (early- EPO and late-LPO) with $p < 0.001$. By Wilcoxon's test, we found differences between preoperative and EPO measurements ($p < 0.01$) and between preoperative and LPO measurements ($p < 0.01$), but not between EPO and LPO ($p = 0.20$).

No reduction or anatomical relations loss of the vertebral segment obtained after reduction and stabilization of the injured vertebral segment were reported. At late assessment, all grafts were integrated to vertebral bodies and the arthrodeses were united. Bone ankylosis was found on joints between posterior facets in 5 patients (25%). Implant loss was seen only in one patient, in whom one of the plate screws loosed after 4 years of surgery, not compromising stability and injury reduction maintenance. Please, note the follow-up for 4 patients selected and commented on the following examples (Figures 8, 9, 10 and 11). Table 3 represents patients' clinical characteristics.

DISCUSSION

The objectives of cervical spine's traumatic injuries treatment have been grounded on decompression of nervous structures and on the stabilization of an injured vertebral segment. The stabilization of an injured vertebral segment allows an early mobilization of the patient, helps on recovering and treating associated injuries, hastening rehabilitation and the return to professional activities. However, there still are some advocates of the use of conservative methods for treating traumatic injuries of the cervical spine [12].

Decompression of nervous structures is the primary specific objective in single-or double-faceted dislocations treatment, especially in patients presenting with neurological injuries, and may be achieved

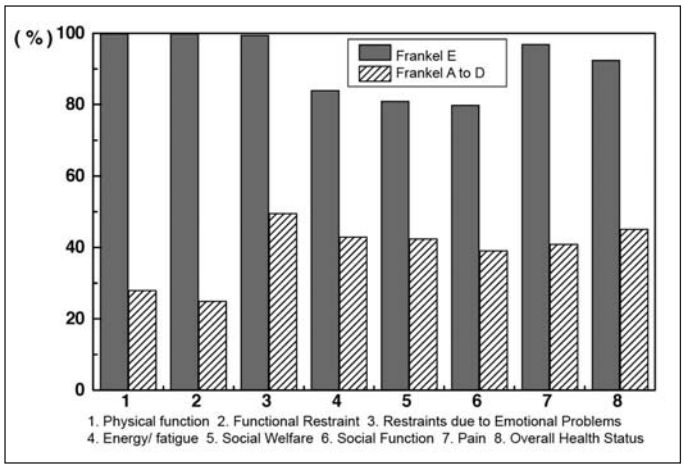

Figure 6 - *Results of the functional evaluation by SF-36 after long-term follow-up, comparing patients with and without neurological deficit.*

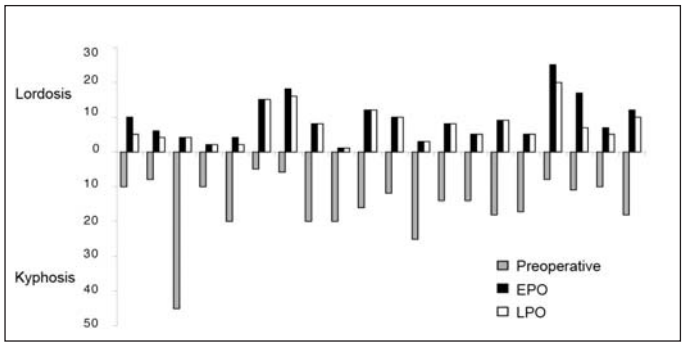

Figure 7 - *Case-case evolution of the lordosis angles among involved segments, comparing preoperative, early postoperative (EPO) and late postoperative (LPO) angles.*

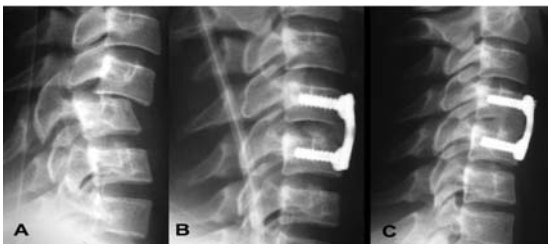

Figure 8 - *Patient number 12. (A) Preoperative X-ray image showing a B1-type, Frankel D injury at C4-C5. (B) Early postoperative X-ray image of the same injury showing reduction and anterior fixation. (C) Postoperative control, after 3 years, showing arthrodesis union, keeping initial reduction.*

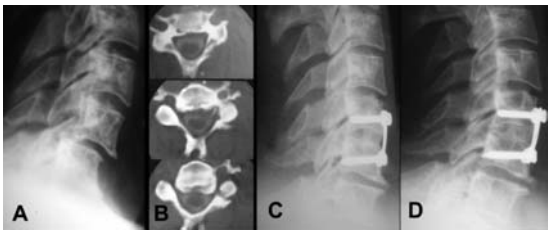

Figure 9 - *Patient number 6. (A) Preoperative X-ray image showing a C1-type, Frankel E injury at C5-C6. (B) The CT image shows a single-faceted fracture-dislocation. (C) Early postoperative image, showing reduction and fixation of the injury. (D) Late follow-up (2 years) keeping reduction and arthrodesis of vertebral bodies.*

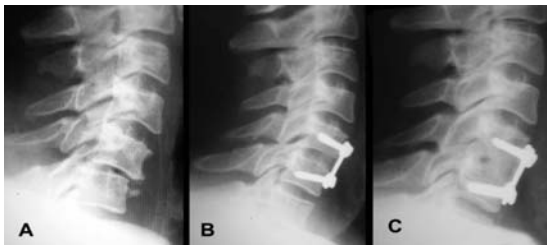

Figure 10 - *Patient number 5. (A) C1-type, Frankel E injury at C5-C6. (B) Reduction and arthrodesis through anterior access. (C) X-ray image one year after surgery showing arthrodesis of vertebral bodies and posterior elements.*

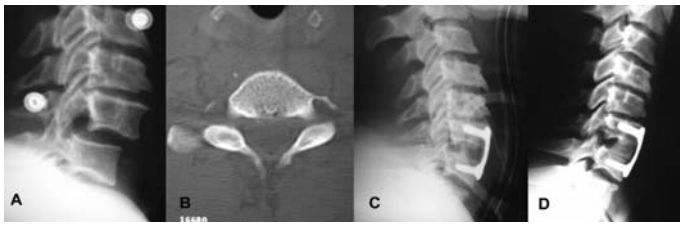

Figure 11- *Patient number 17. (A) B1-type, Frankel E injury at C6-C7. (B) Computed tomography showing dislocation. (C) Reduction with traction performed with cranial halo and arthrodesis via anterior access. (D) Late postoperative control (3 years) showing subtle reduction loss not compromising clinical or functional outcomes.*

							Kyphosis Angle						Frankel			
Patient	Age	Gender	Type	Injury Level	Mechanism of Trauma	Kind of Reduction	Pre-kyphosis	EPO Lordosis	LPO Lordosis	Reduction	Follow-up (years)	Posterior Ankylosis	Early	Late	Denis Pain	Denis Work
1	37	M	B1	C6-C7	Horse fall	Halo	10	10	5	Maintained	4	No	B	D	2	4
2	33	M	B1	C5-C6	High fall	Halo + Open	8	6	4	Maintained	6	No	A	A	2	5
3	43	M	B1	C4-C5	High fall	Halo	45	4	4	Maintained	5	No	A	A	-	-
4	24	M	B1	C4-C5	Shallow water diving	Open	10	2	2	Maintained	14	No	A	A	-	-
5	53	M	C1	C5-C6	Shallow water diving	Open	20	4	2	Maintained	2	Yes	E	E	1	1
6	43	M	C1	C5-C6	Car accident	Halo	5	15	15	Maintained	3	No	E	E	1	1
7	34	M	C2	C4-C5	Car accident	Halo	6	18	16	Maintained	2	Yes	E	E	1	3
8	40	M	C1	C4-C5	Car accident	Halo + Open	20	8	8	Maintained	4	No	E	E	1	2
9	58	M	C1	C5-C6	Car accident	Open	20	1	1	Maintained	2	No	E	E	1	1
10	32	M	C1	C5-C6	Horse fall	Open	16	12	12	Maintained	1,5	No	E	E	1	2
11	39	M	B1	C4-C5	Shallow water diving	Open	12	10	10	Maintained	3,5	No	E	E	1	1
12	25	M	C1	C4-C5	Shallow water diving	Halo + Open	25	3	3	Maintained	4	No	D	E	1	1
13	48	M	C2	C3-C4	Car accident	Open	14	8	8	Maintained	4	No	E	E	1	1
14	11	F	C1	C4-C5	Shallow water diving	Halo	14	5	5	Maintained	4	Yes	E	E	1	1
15	44	M	B1	C6-C7	Car accident	Open	18	9	9	Maintained	3	Yes	D	D	5	5
16	30	M	B1	C4-C5	High fall	Halo	17	5	5	Maintained	3	No	B	C	1	3
17	53	M	B1	C6-C7	Car accident	Halo	8	25	20	Maintained	4,5	No	E	E	1	1
18	26	M	B1	C5-C6	Car accident	Open	11	17	7	Maintained	1	No	A	A	-	-
19	24	F	B1	C4-C5	High fall	Halo	10	7	5	Maintained	3	Yes	A	A	2	3
20	26	M	C1	C5-C6	Car accident	Open	18	12	10	Maintained	4	No	E	E	1	1

Table 3 - *Clinical Characteristics of Patients.*

by means of cervical traction. Setting up cervical traction at the beginning of a patient's follow-up, allows for decompressing nervous structures by means of restoring normal anatomical relations and also by ligamentotaxis effect, and may help on recovering neurological injuries [13,14]. In circumstances where decompression cannot be achieved by means of conservative methods, surgical reduction should be considered and by performing an anterior approach for removing the intervertebral disc mitigates the potential of nervous structures being compressed by intervertebral disc dislocation, which can occur during reduction maneuvers performed through the posterior approach [15]. We had the opportunity to verify this potential risk during surgical procedures performed on patients in whom dislocation reduction was not possible before surgical procedure.

Much is discussed about the best approach for treating cervical spine dislocations, and the anterior or posterior approaches dispute surgeons' preferences. In circumstances where compression of nervous elements exists because of intervertebral disc protrusion or because of vertebral body fragments displaced into the channel, the need of decompressing the vertebral channel would justify an anterior approach. On the other hand, a posterior approach would be preferable for treating irreducible dislocations of the cervical spine, except in cases presenting an associated disc hernia. In circumstances where preoperative dislocation reduction is feasible, potential exists for injury anterior or posterior arthrodesis, and literature describes advocates of both approaches. Studies have been conducted aiming to compare both approaches, and the clinical outcomes are reported to be similar in both techniques, suggesting that the decision towards a specific approach would be a particular subjective judgment of the surgeon [16,17].

Stabilization of an injured vertebral segment by means of instruments and arthrodesis has enabled immediate restoration of vertebral stability and the maintenance of a bone graft positioning while arthrodesis union happens. From a biomechanical perspective, posterior fixations have been proven to be superior compared to anterior fixations in *in vitro* tests, but such mechanical superiority apparently does not influence clinical outcomes [18].

The clinical outcomes seen in our patient series are consistent to reports on pertinent literature, suggesting a high percentage of good clinical and functional results, high rates of arthrodesis union [19].

The anterior approach has been our selection for treating single or double-faceted dislocations of the low cervical spine, not because of the superior outcomes it provides compared to the posterior approach, but for the technical aspects related to it. Considering that the objective of a surgical therapy is decompression, reduction and stabilization of a vertebral segment, all these objectives may be accomplished by means of the anterior approach, which would provide the advantage of positioning the patient at dorsal decubitus and of the anterior access, avoiding dissection of the whole posterior musculature. Through anterior approach, implants placement is technically easy, and the stability provided by fixation enables postoperative mobilization of patients, achieving arthrodesis union, reduction maintenance, high rates of good outcomes, and low complication rates.

CONCLUSION

Surgical treatment by means of anterior approach and fixation for single or double-faceted dislocations of the cervical spine presented a high rate of good outcomes according to the parameters used in the evaluation (clinical, X-ray-related, and functional) and a low complication rate.

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