

SURGICAL MANAGEMENT OF AXIS' TRAUMATIC SPONDYLOLISTHESIS

Hangman's fracture

José Luiz Romeo Boulosa¹, Benedicto Oscar Colli², Carlos Gilberto Carlotti Jr³, Koji Tanaka¹, Marcius Benigno Marques dos Santos¹

ABSTRACT - Objective: To evaluate the results of surgical treatment using pedicle screws going through C2 pedicles for fixating the spondylolisthesis of the axis in patients who presented pseudoarthrosis after clinical treatment, or who have no condition for fixation with "halo vest", due to serious head trauma. **Method:** Ten patients have been operated from June 1998 to April 2002, nine suffering from traumatic spondylolisthesis of the axis caused by car accident and one horse fall. Four of those patients have undergone clinical treatment and presented signs of pseudoarthrosis, suffering intense pain at the movement of the cervical spine. Two of them presented moderate head trauma with multiple fractures of the skull. Another one was submitted to a surgical treatment for an acute extradural hematoma. Three patients presented a serious dislocation of C2 over C3. The patients were submitted to arthrodesis of the fractures with two screws, placed on the C2 pedicles, which allowed a better approximation of the fractures with the alignment of C2-C3. Two other patients required additional fixation with a plate on the lateral masses of C3. **Results:** Nine patients had a good post surgery evolution with satisfactory consolidation of the fractures and disappearance of the symptoms. One patient had a good evolution but still has cervical pain resulting from strain. **Conclusion:** The fixation of the traumatic spondylolisthesis of the axis using screws in C2 pedicles and through fractures traces is a good option for treating patients who present pseudoarthrosis after clinical treatment or who present contraindication to the "halo vest", such as skull fracture or great lacerations in the scalp.

KEY WORDS: cervical spine, traumatic spondylolisthesis of the axis (Hangman's fracture), cervical arthrodesis, raquimedullar trauma.

Tratamento cirúrgico para a espondilolistese traumática do eixo (fratura do enforcado)

RESUMO - Objetivo: Avaliar os resultados do tratamento cirúrgico usando parafuso com rosca parcial, atravessando os pedículos de C2, para a fixação da espondilolistese traumática do eixo, em pacientes que apresentam pseudoartrose após o tratamento clínico, ou que não tiveram condições de fixação com "halo vest" devido a traumatismo crânio-encefálico importante. **Método:** De junho de 1998 a abril de 2002, foram operados dez pacientes com espondilolistese traumática do eixo. Nove foram vítimas de acidentes automobilísticos e um sofreu queda de cavalo. Quatro pacientes tinham sido submetidos a tratamento clínico, e apresentavam sinais de pseudoartrose, com dor intensa à movimentação da coluna cervical. Dois apresentavam traumatismo crânio-encefálico moderado com múltiplas fraturas de crânio. Um foi submetido a tratamento cirúrgico de hematoma extradural agudo. Três apresentavam deslocamento importante de C2 sobre C3. Os pacientes foram submetidos a artrodese das fraturas com dois parafusos de rosca parcial colocados nos pedículos de C2, atravessando-se as fraturas, o que permitiu melhor aproximação das fraturas com alinhamento de C2-C3. Em dois pacientes foi necessária a fixação adicional com placa lateral fixa nas massas laterais de C3. **Resultados:** Nove pacientes tiveram boa evolução pós-operatória com consolidação satisfatória das fraturas, e desaparecimento dos sintomas. Um paciente teve boa evolução com consolidação das fraturas, mas permanece com dores cervicais aos esforços. **Conclusão:** A fixação da espondilolistese traumática do eixo com o uso de parafusos de rosca parcial, nos pedículos de C2 e através dos traços de fratura é uma boa opção para o tratamento de pacientes que apresentarem pseudoartrose após tratamento clínico, ou apresentam contraindicações para o uso do "halo vest", como fraturas da calota craniana, ou grandes lacerações de couro cabeludo.

PALAVRAS-CHAVE: coluna cervical, espondilolistese traumática do eixo, fratura de Hangman, fratura do enforcado, artrodese cervical, traumatismo raquimedullar.

Hospital das Clínicas da Faculdade de Medicina de Ribeirão Preto, Neurosurgery Division, University of São Paulo, Ribeirão Preto SP, Brazil: ¹Staff Physician; ²Assistant Professor Neurosurgery Division; ³Full Professor

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Dr. José Luiz Romeo Boulosa - Rua Visconde de Inhaúma 1650 - 14025-100 Ribeirão Preto SP - Brasil. E-mail: jlromeo@netsite.com.br

Table 1. Patients with axis' traumatic spondylolisthesis treated with surgical fixation with pedicular screws, from June 1998 to April 2002.

Patients	Age (years)	Sex	Date of the accident	Type of accident	Hospital	Indication for surgery	Classification (Effendi, et al.)	Date of surgery	Surgery performed	Time of hospitalization	Time of follow-up
PJV	38	M	19/09/97	Vehicle	HSFco	Pseudoarthrosis	Type I	23/06/98	C2 Pedicular screws	5 days	55 months
VBS	25	M	05/03/98	Vehicle	HCRP	Pseudoarthrosis	Type II	17/11/98	C2 Pedicular screws	6 days	49 months
WRS	42	M	20/08/99	Vehicle	HSFco	Severe Head injury	Type I	27/08/99	C2 Pedicular screws	17 days	40 months
SDM	21	M	15/07/99	Vehicle	HSFco	Pseudoarthrosis	Type II	02/03/00	C2 Pedicular screws	4 days	33 months
AJNF	31	F	23/05/00	Vehicle	HSFco	Great dislocation onC2-C3	Type II	26/05/00	C2 Pedicular screws with plates fixing on C3 lateral mass	7 days	31 months
OAS	40	M	12/01/01	Vehicle	HCRP	Severe head injury	Type II	22/01/01	C2 Pedicular screws	19 days	23 months
CCP	52	F	11/02/00	Vehicle	HSFco	Pseudoarthrosis	Type II	30/08/01	C2 Pedicular screws	5 days	16 months
JAM	25	M	01/10/01	Vehicle	HCRP	Severe head injury (Extradural hematoma)	Type II	09/10/01	C2 Pedicular screws	7 days	14 months
JMS	32	M	26/03/02	Vehicle	HCRP	Great dislocation onC2-C3	Type II	29/03/02	C2 Pedicular screws with plates fixing on C3 lateral mass	7 days	9 months
JCPS	51	M	23/04/02	Horse fall	HSFco	Great dislocation onC2-C3	Type II	27/04/02	C2 Pedicular screws	5 days	8 months

"Hangman's fracture" and Axis Traumatic Spondylolisthesis (ATS) are terms which have been used to describe a specific fracture group, which involve the posterior C2 elements¹. Wood-Jones, in 1913, described the C2 vertebrae fracture produced by the hanging in an article entitled "The ideal Lesion Produced by Hanging" observing that the lesion was produced by the violent cervical traction with the abrupt stretching of the head backwards, causing the C2 pedicle fractures². In 1964, Garber³ described C2 pedicle fractures with the forward dislocation of the C2 body in patients victims of motor vehicle accidents, what was denominated "Axis' Traumatic Spondylolisthesis". In 1965, Schneider et al.⁴ described a new series of patients with the same fractures described by Wood-Jones and by Garber, denominating it "Hangman's Fracture".

The ATS was referred to as an uncommon and predominantly stable lesion, rarely accompanied by neurological deficit, for which the recommended treatment was the cervical traction and rigid immobilization^{3,4}. Studies indicated that these kinds of traumatic lesions are a frequent consequence of motor vehicle accidents and falls, corresponding from 7 to 20% of cervical fractures, and from 20 to 23% of (C2) axis' fractures^{5,6}.

A simple cervical spine lateral X-ray can diagnose the majority of the cases. Computed axial tomography of the cervical column with bone window can show more details of the lesion^{7,8}. Even though

some authors suggest surgical treatment to all Hangman's Fracture cases⁹. The majority of them agree that in most cases the conservative treatment is the most indicated, either with use of semi-rigid collars in cases of a small degree of dislocation, or rigid immobilizations like the "halo-vest", in cases of great luxations^{5,6,10-12}.

Nevertheless, in some cases the conservative treatment may not produce a satisfactory fracture consolidation, resulting in pseudoarthrosis, which can present pain not only during head movement but also during rest, or produce great luxations endangering the cervical canal or medullar compression^{5,10,12-21}. Another problem is the sprains of C2 over C3, for which a conservative treatment with good alignment cannot be obtained. In addition, patients with ATS needing neurosurgical procedures or showing skull fractures or still acute scalp lesion usually cannot be submitted to treatment with external immobilization. In these cases, surgical treatment can be a good option. Various surgical techniques were suggested, starting from the occipito-cervical fixing by posterior approach with the use of metal implants and bone graft, up to the C2-C3 anterior fixied by trans-oral aproach¹³⁻¹⁷. Laconte et al.²¹ describe the C2 direct pedicles fixing technique for the ATS. It is a technique which preserves the cervical column mobility and that can offer good results in terms of alignment and effective fixing with a low level of pseudoarthrosis^{14,19,22}.

The objective of the present study is to evaluate the results of the surgical treatment with partially threaded screws passing through the C2 pedicles, for the fixing of the Axis' Traumatic Spondylolisthesis.

METHOD

Casuistics

From June 1998 to April 2002, ten patients with ATS have been operated. Four patients were admitted and operated on at São Paulo University Medical School "Hospital das Clínicas" Emergency Unit from Ribeirão Preto, and six patients were seen and operated at São Francisco's Hospital (in the city of Ribeirão Preto).

The age of the patients varied from 25 to 52, with an average age of 35.7 years. Eight patients were males and two were females.

Nine patients were motor vehicle accident victims and one was a victim of a horse fall. Four patients had been submitted previously to conservative treatment, and showed signs of pseudoarthrosis, with intense pain in the cervical spine. Three patients showed head injury, two of them with multiple cranial fractures and the third one was submitted to surgical treatment for acute extradural hematoma. Three showed important C2 over

C3 dislocation which was not reduced satisfactorily with the conservative treatment.

None of the patients showed neurological deficit. The details of each case are shown on Table 1.

Procedure

All of the patients were submitted to simple X-rays and computed tomography of the cervical column, confirming the C2 pedicle fracture diagnosis, without compromising the vertebral body from the same vertebrae. In the cases of pseudoarthrosis after the conservative treatment, dynamic x-rays of the cervical column (bending and stretching) were also performed aiming to confirm a flaw in the fracture's consolidation.

All of the patients were operated by the head author.

Surgical technique - All of the patients were submitted to C2 pedicle arthrodesis, a screw fixed on each pedicle crossing the fracture lines, with the technique described by Laconte et al.²¹. The patient is positioned in the ventral decubitus with the face resting on a cranial support iron tool or with the head fixed by a Mayfield type support, keeping the best possible C2-C3 alignment. Continuous cervical radioscopy on lateral view is obtained during the surgery to see in specially the C2's pedicles and body. The incision is made on the median line with the extension of approximately 8 cm, centered on C2, on the cervical spine posterior face. The C2 articular masses are exposed and a electric scalpel is used to detach the para-vertebral musculature. Two holes are made with a drill connected to a light drilling machine, or to a high-speed motor, one in each articular mass, in its central part. The drilling is then proceeded towards the C2 vertebral body keeping an inclination of approximately 20 degrees in the axial plane and approximately about 20 degrees in the sagittal plane (Fig 1). This last

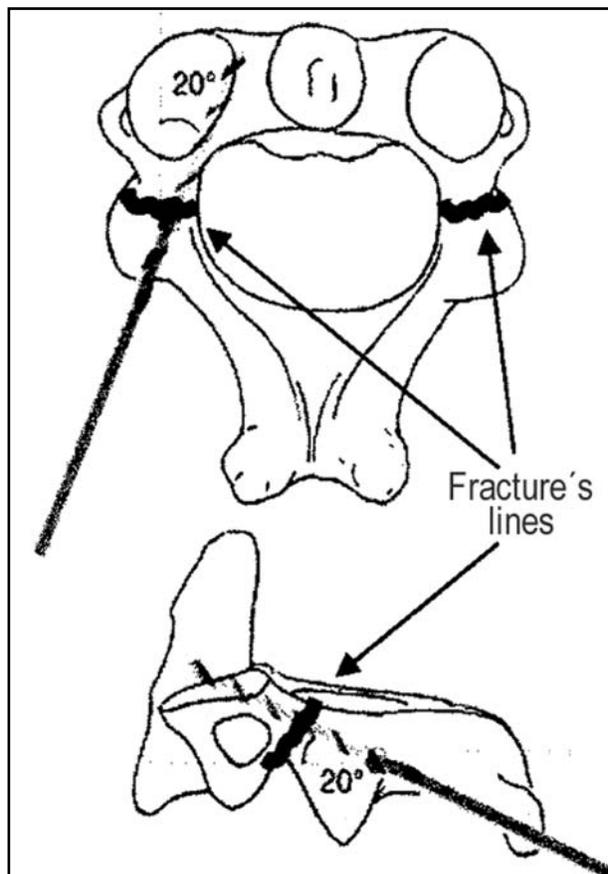


Fig 1. Scheme showing the trajectories and angulations of the drill, avoiding neurovascular lesions.

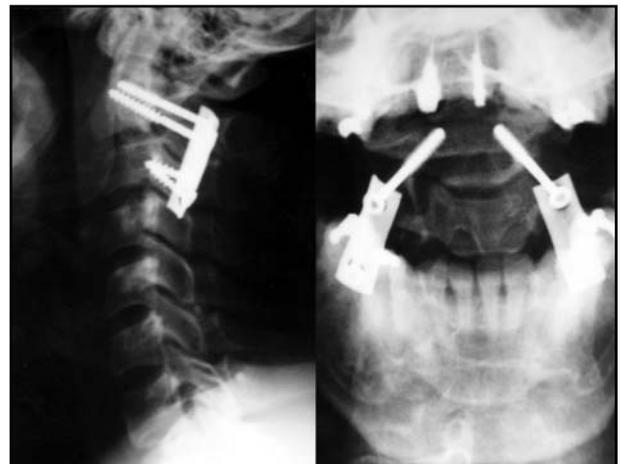


Fig 2. Lateral cervical radiography (A) and frontal radiography (B) pos-surgical showing a Axis Traumatic Spondylolisthesis treated with the passage of 2 screws in the C2 pedicles, and 2 screws on the lateral masses of C3, and 2 plates fixing C2-C3, with a good reduction of the deformity.

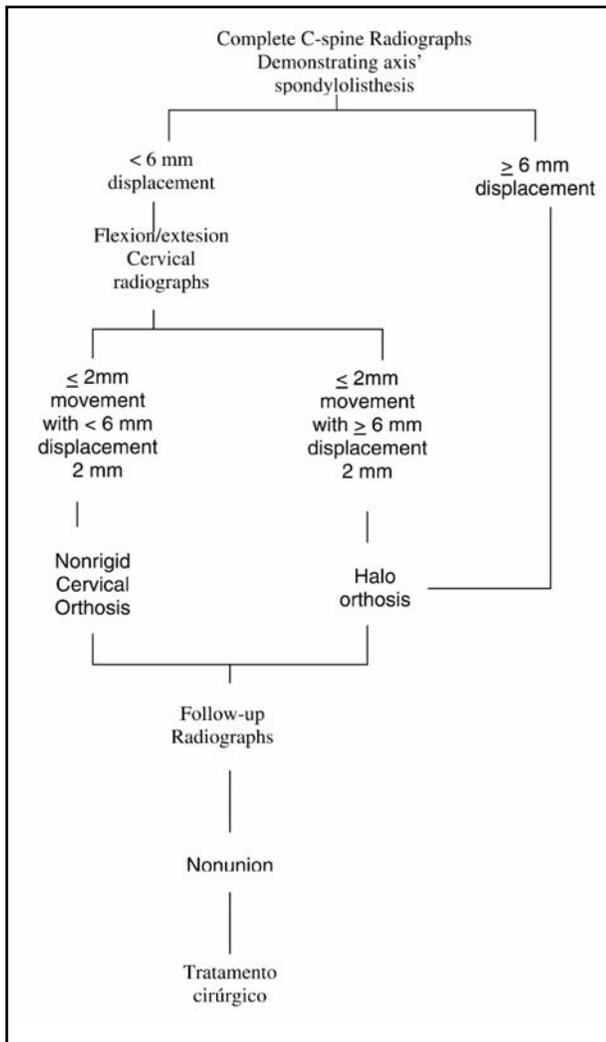


Fig 3. Fluxogram showing the treatment algorithm for the management of axis' traumatic spondylolisthesis suggested by Coric et al. (1996)¹.

inclination has to be followed by the continuous X-rays, in order to keep the drill strictly within the C2 pedicles. In each of those two trajectories, the "guiding wires" are inserted. These wires will guide the two 3.5mm diameter canulated screws, with the thread only at the end (called partial thread screws). The correction and the fracture fixing are better obtained when the 2 screws are fixed simultaneously, pulling in an equal manner the C2 vertebral body towards the fractured pedicles. Cases that the sprain reduction becomes more difficult, a lateral mass plate can be added connecting the C2 pedicle screws to 2 lateral mass ones on the C3 as described by Roy-Camille et al.²³. On these series, in only 2 cases we needed to add the C3 fixing for a better sprain reduction (Fig 2).

All the patients used a semi-rigid cervical collar (Philadelphia collar) for a period of 30 days.

Follow up - The patients were reevaluated clinically 30, 60, 90 and 180 days after the surgery. Since the

evolution was satisfactory, the subsequent follow-ups were set up on a yearly basis. On the follow-ups, physical and neurological exams, the pain complaints or paresthesia as well as the cervical column mobility were also evaluated. The patients were also asked about their satisfaction level with the surgery.

Radiological control was done on the second post-operative day as well as on the scheduled follow-ups.

The clinical follow-up period varied from 8 to 55 months.

RESULTS

Nine patients had good post-operative improvement with satisfactory fracture consolidation, and the total disappearance of the symptoms.

There was no intra or post-operative complication, except with a patient who showed lung infection on the 3rd post-operative day, which decreased in 7 days of antibiotic-therapy treatment.

The hospitalization period varied from 4 to 19 days.

Only one patient indicated frequent cervical pain, mainly when intense physical effort was done, what improved with rest and the use of non-steroid analgesics.

On the check-up X-rays, all of the patients showed satisfactory consolidation signs after six months of surgery.

All of the patients mentioned being satisfied with the surgery, and declared that if necessary, would submit themselves again to the same procedure.

DISCUSSION

Since Schneider et al. correlated the occurrence of the C2 pedicle fractures with motor vehicle accidents and falls, and used the term "Hangman's Fracture" due to the similarities with the fractures that occurred on the cervical column of hanged individuals^{11,16,23}. Today, 50 to 80% of the axis' traumatic lesions are resulting from motor vehicle accidents, and 10 to 40% are due to great falls^{4, 6,24,25}. The majority of the authors consider this fracture to be generally stable, with good prognosis and generally conservative treatment^{4,5,18,25}. They are rarely accompanied by neurological lesions, once the pedicles fractures promote a widening of the vertebral canal in that area^{4,5}. The ATS is also associated with a high incidence of head injuries and other cervical traumas (79%)^{18,26}. The rare important C2 over C3 sprain cases occur by the ligament rupture of the C2-C3 disc, and spinal cord compression can occur^{12,16-18}. On these cases, the fracture would become unstable and a surgical treatment indication on the acute lesion phase can be discussed^{11,18,24,25}.

The stable and unstable classification of these lesions can help with indication of a surgical or conservative treatment¹. Nowadays, the most widely used classification for ATS is from Effendi et al.²⁴ and Levine & Edwards²⁵, which modified Effendi et al classification. Both classifications take into account fractures' action mechanism and the lesion seriousness, and can be of help in choosing the best treatment for each case. Type III fractures are the rarest. Levine & Edwards subdivided the Type III in three variations: 1) bipedicular fractures with bilateral dislocation of the articular facets. 2) unilateral facet of the articular facets or combined dislocations with a neural arch contralateral fracture. 3) bilateral dislocation of the articulate facets associated with the C2 bilaminar fractures. On both classifications, the Type I lesions are classified as stable and Type II and III as unstable^{1,24,25}.

The majority of the authors suggest that the first ATS treatment is rigid immobilization (halo-vest, i.e.)^{5, 6, 10-12, 16, 19, 27}. It is a kind of immobilization that produces a high level of fracture consolidation, with a pseudoarthrosis level of about 5%¹⁵. Choric et al.¹ suggest a fluxogram for the ATS' treatment (Fig 3). In this work, Coric et al. come to an agreement that the majority of the patients with the ATS diagnosis can be treated with non-rigid immobilizations (Philadelphia collar i.e.)¹. Grady et al. also consider that the major part of these patients can be treated with the use of the Philadelphia collar²⁸.

Several surgical techniques have been described for the ATS fixing. Some authors suggest the anterior approach, with a bony graft insertion in the C2-C3 space, and segment fixing with anterior plates²⁹.

Wilson et al.²¹ described the C2-C3 disc transoral approach, and the C2-C3 fixing with bony graft and a titanium anterior cervical plate. The result was satisfactory, but it deals with a complex technical surgery. The access way demands great surgical knowledge with the local anatomy, and it is followed by a relatively high level of morbidity. For us, these previous approaches would only be indicated in cases of complex axis' fractures, involving the C2 body.

The majority of the authors prefer the posterior fixation, such as the passing of the metal wires, tying the C1 to C3 spin apophysis, hind head fixation to C3, using metallic implants (Luque's rectangle), or pedicular screws in C3 lateral masses, all using bone graft to consolidate the fracture^{13, 16}.

The direct C2 pedicle fixation to the ATS described by Laconte et al.¹⁹ preserves the cervical column mobility and can obtain good results for alignment and effective fixation with low pseudoarthrosis level^{14, 19, 22}. The biggest risk described in the literature, for this procedure is the occurrence of neurovascular lesions (vertebral artery lesion or penetration into the vertebral canal)^{1, 13, 14, 23}.

Ebraheim et al.¹⁷ showed that the pedicular screws passage through to the C2 medial and superior portion of the pedicles is a safe procedure. To attain more safety during this procedure, Taller et al. suggest the pedicular screw passage guided by computed axial tomography³⁰. Roy-Camille et al.²³ described the C2-C3 fixation in the cases of the ATS using two lateral mass plates, fixed with a passage of two screws in the C2 pedicles and two screws in the C3 lateral masses.

In our series, it is to be noted that nine of the patients had motor vehicle accidents, and 1 patient fell from a horse, which coincides with the literature, since the majority of the patients with ATS are victims of these accidents or falls.

In our opinion, the conservative treatment is the initial management in the most of the ATS cases, as the majority of the cited authors suggest. We believe that the use of C2 pedicular screws, isolated or in connection with lateral mass plaques, is a good approach for the resolution of specific cases, such pseudoarthrosis after the conservative treatment with great fracture instability and for patients with head injuries that do not allow the use of the halo-vest.

In this series, the post-operative improvement showed to be satisfactory, with only one patient complaining of pain during the clinical evolution. The pain appeared when he executed activities, which demanded some kind of major physical effort. This patient had a great sprain and was submitted to arthrodesis in the acute phase with the use of plates, C3 lateral mass screws and hipbone crest graft. The post-operative X-rays showed the fracture consolidation and the bone graft incorporation.

During the surgical procedures, there was not any vascular or neural structure lesions. Even with the risk being always present and being inherent to the procedure, the correct angular position during the drill and the screws passage, the careful planning of the procedure in the pre-operative phase and the visualization of the pedicles with the

use of continuous radioscopy on lateral view prevented this kind of lesion.

In patients with pseudoarthrosis (four), the interval between the accident and the surgery was from 8 to 18 months (with an average of 10.7 months). In spite of the relatively long period, the four cases had good evolution with their fracture consolidation and complete remission of their pre-operational symptoms.

The hospitalization period was relatively short (4 to 19 days with an average of 8.2 days) and the need for longer hospitalization was due to the head trauma and not because of the surgical procedure. The fixing of the fractures in patients with severe head trauma facilitated the work of the nursing and physical therapy staff, allowing early mobility of the patients, their removal from the bed, reducing the morbidity of the lesions.

CONCLUSION

The fixing of Axis' Traumatic Spondylolisthesis by means of screws with partial threads, in the C2 pedicles through the fracture line is a good option for patient that presents pseudoarthrosis after clinical treatment or presents contra-indication for the use of "halo-vest", like skull fractures or greater scalp lacerations.

The procedure offers a good initial stability and produces a high rate of fracture consolidation.

In cases where the instability is higher or with difficulty in decreasing the luxation, the association with plates and screws for lateral mass in C3 gives a more effective fixation.

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