The EGYPTIAN SPINE Journal

Online ISSN : 2314-8969
Print ISSN: 2314-8950
www.esj.journals.ekb.eg

CLINICAL ARTICLE EgySpineJ 31:36-44, 2019 DOI: 10.21608/esj.2019.12243.1097

Posterior C1–C2 Temporary Fixation without Fusion for Recent Type–II Odontoid Fractures

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ABSTRACT

Background Data: Posterior C1-C2 fusion techniques are the commonly used treatment for odontoid fracture. This procedure is usually associated with limitation in the cervical spine range of motion (ROM) especially the rotational motion. Posterior C1-C2 temporary fixation technique can spare the range of motion of the atlantoaxial joint after odontoid fracture healing is complete.

Purpose: To assess the clinical and radiological outcome of the posterior C1-C2 temporary fixation technique in the treatment of a new odontoid fracture.

Study Design: It is a retrospective study with clinical and radiological evaluation before and after instrumentation removal.

Patients and Methods: Twelve consecutive patients, suffering from type-II odontoid fracture, were retrospectively recruited for this study. The age ranged between 15 and 43 years with a mean age being 24±11.6 years. Eight patients were males and four were females. All cases suffered from acute posttraumatic type-II dens fracture. Eight patients suffered from reducible subluxation and four cases were in place. Only two patients were suffering from partial neurologic deficit preoperatively (grade 4). All patients were submitted to Harms' atlantoaxial fixation procedure. Surgical removal of the implants was done after a mean of 15.5 (range, 12–20 weeks) weeks from the first surgery. All patients had MSCT scan to assess healing and then dynamic MSCT scan after removal to assess C1-C2 ROM.

Results: All of our twelve patients completed the two procedures without significant events. Two patients with preoperative neurological illness had improved gradually with physiotherapy. All patients had complete healing of their factures. Postoperative dynamic CT scan showed partial restoration of the rotation after removal of instrumentations with a mean total rotation restoration of 30±8°. Significantly better functional outcomes were observed after the temporary fixation removal using Visual Analog Scale (VAS) score for neck pain (P=0.0033), neck stiffness, and the patient satisfaction.

Conclusion: Posterior atlantoaxial temporary fixation is a good salvage approach in dealing with odontoid fracture, especially when anterior odontoid screw is contraindicated. By regaining partial ROM, the functional outcome of the patients improved. (2019ESJ187)

Keywords: Odontoid fracture, dens fracture, temporary fixation, C1-C2, atlantoaxial, range of motion.

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Submitted: April 24th, 2019
Accepted: June 15th, 2019
Published: July 2019

The article does not contain information about medical device(s)/drug(s).
No funds were received in support of this work.
The authors report no conflict of interest.

INTRODUCTION

Odontoid fractures are a common form of spinal injury; they account for 10–20% of all cervical injuries.[11] The best surgical treatment for an unstable atlantoaxial fracture due to odontoid fracture is still a matter of debate. The difficulty in this issue is that the anatomy of C1 and C2 differs from the rest of the subaxial cervical spine. There are controversies about using odontoid screw to preserve the range of motion especial in axial rotation and rigid fixation posteriorly to achieve sound fusion.[7,21] Unfortunately, the odontoid screw is contraindicated in certain trauma such as comminuted fracture of the odontoid, Grauer's type-IIC fracture, transverse ligament rupture, nonreducible fractures, nonunion persisting longer than 3 months, osteoporosis, and body habitus conditions such as barrel chest, short neck, and severe thoracic kyphosis.[1,4,23]

The maximum normal axial rotation reported between C1 and C2 was around 40° to each side. This accounts for 50% of the rotation in the cervical spine. Rotation of the atlas on the axis does not occur without a small degree of extension and lateral flexion and sometimes flexion.[22]

Both flexion and extension movements are reported to be initiated in the lower cervical spine. Biomechanical studies showed that C1-C2 rotation is not a monoplaner motion, but is coupled with flexion, extension, and lateral bending. So, in left rotation, right lateral bending and extension were coupled. In right rotation, left lateral bending and extension were coupled.[14,28]

Cervical spine flexion and extension often create motion in the direction opposite that is being experienced in the atlas. Thus, when the cervical spine is flexing, the atlas extends, and when the cervical spine extends, the atlas flexes.

Because of the importance and the great role of C1-C2 in axial rotation, especially in young adults, we think that more attention should be paid to the technique of temporary posterior fixation.

PATIENTS AND METHODS

A retrospective study of 12 consecutive patients suffering from odontoid fracture has been performed. The study was approved by the ethics committees of our hospital, and each patient provided informed consent. The study included patients with type-II odontoid fracture according to Anderson and D'Alonzo[2]. Exclusion criteria were rheumatoid arthritis, severe degeneration within the atlantoaxial joint, ligamentous disruption within the atlantoaxial joint, associated severe neurological deficit, severe head injury, and failure of complete reduction of dislocation following instrumentation.

All the patients had preoperative thorough clinical examination, cervical spine plain X-ray (anteroposterior, lateral, flexion, and extension), Multislice Computed Tomography (MSCT) scan (including coronal and sagittal reconstructions), and MRI of the cervical spine.

All patients were submitted for posterior atlantoaxial fixation according to the method of Goel[6] and Harms[12], where two screws were placed within the lateral masses of the atlas and two screws placed via the C2 pedicles or the C2 isthmic area. We used polyaxial lateral mass screw with rod systems, made by an Egyptian company. The screws were applied away from C2-C3 facet joint, to avoid facet arthrosis and gain benefit from removal later on. Then the patients used a Philadelphia collar postoperatively for 8 weeks.

Good odontoid healing and complete fusion were assessed by a follow-up MSCT scan with sagittal and coronal reconstruction, showing bridging bone across the odontoid fracture site. This was done after 10 weeks from first assessment, and then again after 6 weeks, if healing is not complete. Time to fracture healing was recorded and this was the time when we removed the implants.

After a mean 15.5±3.5 weeks, the implants were removed and follow-up rotational (dynamic) MSCT to the right and left scan was done a week

later to measure the range of motion (ROM) at C1-C2 level.

The range of motion in rotation of C1-C2 was measured on axial CT scan using Heiko Koller method,[15] where the C1 and C2 angle is the midsagittal line of C1 and C2 calculated to the vertical axis, respectively; this angel indicates the maximum rotation of the atlas and axis to either side, by subtracting the axis angel from that of the atlas; we get the rotatory ROM of the atlantoaxial joint to one side. The summation of both sides is the total rotatory ROM. The atlantoaxial stability was evaluated on flexion-extension lateral radiographs. Cervical spine plain X-ray was done at 3 months and 6 months and 1 year postoperatively.

Functional outcome was assessed using Visual Analog Scale (VAS)[13] for neck pain, neck stiffness (none/mild/severe),[16] and patient satisfaction,[19] comparing the before and after instrumentation removal results. Data was collected and analyzed.

RESULTS

The 12 patients' mean age was 24±11.6 years old; eight were males and four females. Fracture healing was achieved and implants were removed at a mean time of 15.5±3.5 weeks from the primary surgery (Figures 1 and 2). There were no neurological complications reported after surgeries.

The ROM was measured using rotational CT scan of C1-C2. The ROM angle of right rotation ranged from 7 to 18 degrees with a mean of 14±3.9°, while the ROM angel of left rotation ranged from 8 to 19 degrees, with a mean 15±4.4°. The mean of total left to right ROM was 30±8° (Figure 3).

The VAS of the neck pain was low in before and after instrumentation removal but was significantly lower after the temporary fixation removal (P=0.0033), where the VAS after the first surgery ranged between 0 and 3 with a mean of 1.5±1, while, after instrumentation removal, the VAS ranged between 0 and 1 with a mean of 0.5±0.5. Also neck stiffness changed significantly after removal of the implants. Patients after the first surgery reported severe (N=2), mild (N=5), and no (N=5) neck stiffness, while most of the patients (nine patients) did not suffer from any neck stiffness after instrumentation removal, and no one had severe neck stiffness (Figure 4). Moreover, patient satisfaction improved from a mean of 7±1.4 after first surgery to a mean of 9±0.9 after implants removal in the second surgery. There was no evidence of C1-C2 instability on flexion-extension radiographs. All the patients' data are summarized in Table 1.

Table 1. Summary of demographic and clinical data of our patients.

Cases	Sex	Age	Duration	ROT RT	ROT LT	ROT total	VAS postoperatively	VAS after screw removal	Neck stiffness postoperatively	Neck stiffness after screw removal	Satisfaction postoperatively	Satisfaction after screw removal	Follow-up
1	M	54	20	9	8	17	3	1	S	M	4	7	28
2	M	19	13	18	15	33	1	0	N	N	7	9	36
3	M	33	15	15	19	34	2	0	M	N	6	9	42
4	F	18	12	18	17	35	0	0	N	N	7	9	24
5	F	20	12	15	18	33	1	0	M	N	8	10	30
6	M	25	12	10	8	18	0	0	N	N	8	9	24
7	M	20	14	12	13	25	1	1	N	N	7	9	36
8	M	28	16	15	17	32	2	1	M	N	8	9	40
9	M	23	16	13	15	28	2	1	M	N	7	9	26
10	F	44	20	7	8	15	3	1	S	M	5	7	24
11	M	18	16	15	17	32	1	0	N	N	8	10	42
12	F	37	20	7	8	15	2	1	M	M	5	8	40
Mean		24	15.5	14	15	30	1.5	0.5			7	9	33
SD		11.6	3.1	3.9	4.4	8	1	0.5			1.4	0.97	7.4

DUR: duration between first and second surgery; **ROM RT**: rotational range of motion angle to the right; **ROM LT**: rotational range of motion angle to the left; **ROM TOT**: total rotational range of motion angle; **VAS 1**: Visual Analog Scale score after first surgery; **VAS 2**: Visual Analog Scale score after second surgery; **NS1**: neck stiffness after first surgery; **NS2:** neck stiffness after the second surgery; **SAT1**: patient satisfaction after first surgery; **SAT2**: patient satisfaction after second surgery; **FU**: follow-up after second surgery.

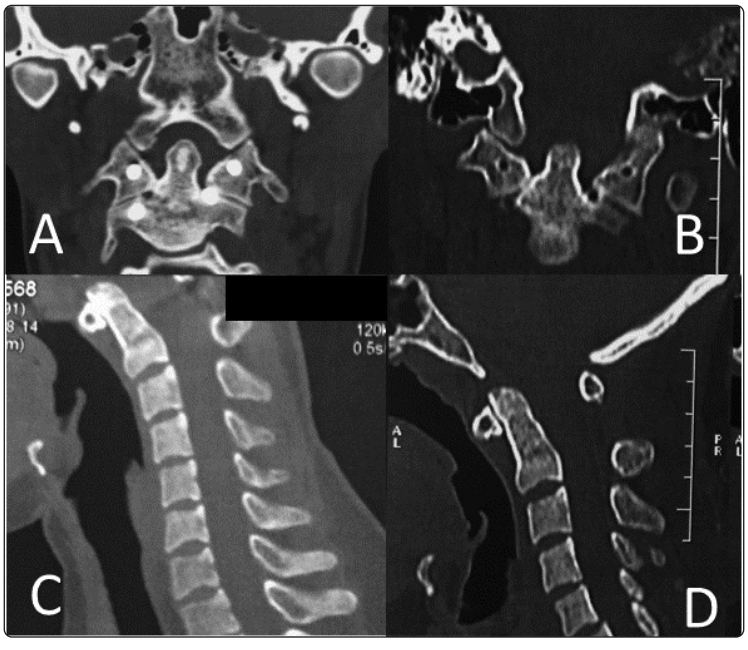

Figure 1. A 20-year-old female patient suffering from odontoid fracture after road traffic accident. (A,C) Coronal and sagittal CT scan showing fusion of fractured odontoid and the screws at C1-C2. (B,D) Coronal and sagittal CT scan after screws and rods removal.

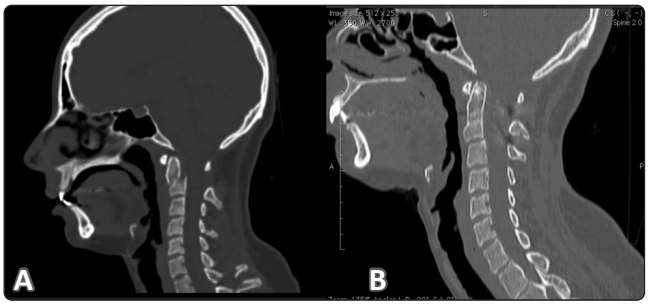

Figure 2. An 18-year-old female patient. (A) Sagittal CT scan shows posttraumatic type-II fracture dislocation of the odontoid. (B) 12 weeks later after good reduction, healing, and fusion, rods and screws were removed.

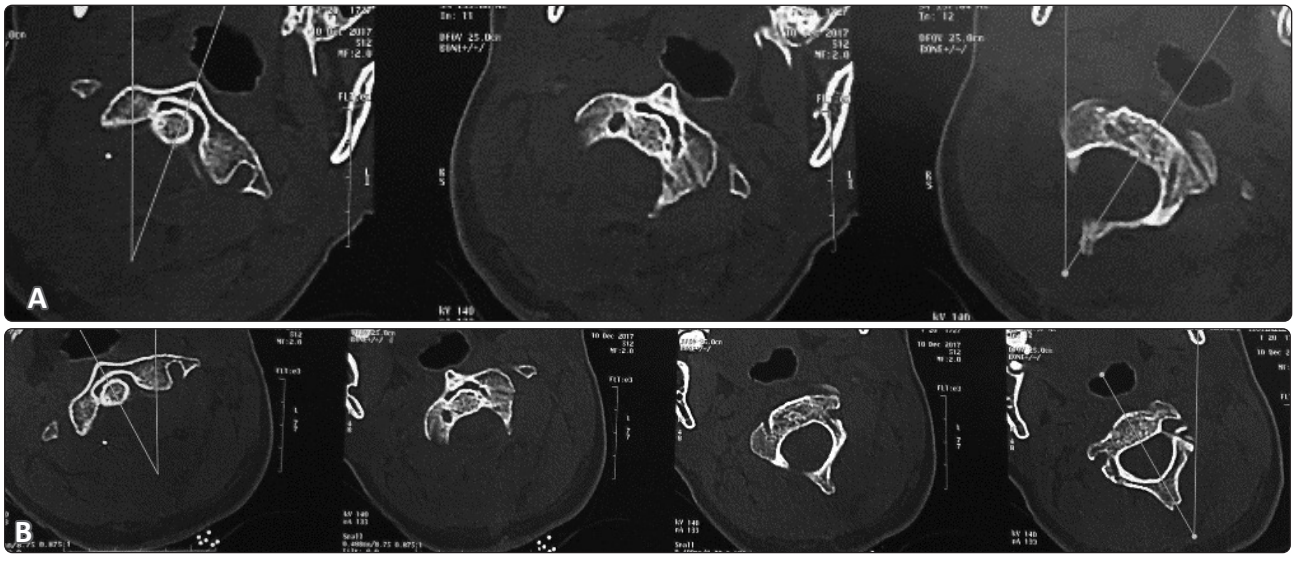

Figure 3. Female patient in figure 2, with left and right rotational CT scan to assess mobility at C1-C2 level after screws and rods removal. (A) Axial CT scan showing left rotatory ROM, by subtracting C1 angle (22°) from that of C2 (35°), which equals 13°. (B) Axial CT scan showing right rotatory ROM, by subtracting C1 angle (20°) from that of C2 (32°), which equals 12°. The total ROM is the summation of both angles (i.e., 13°+12° = 25°).

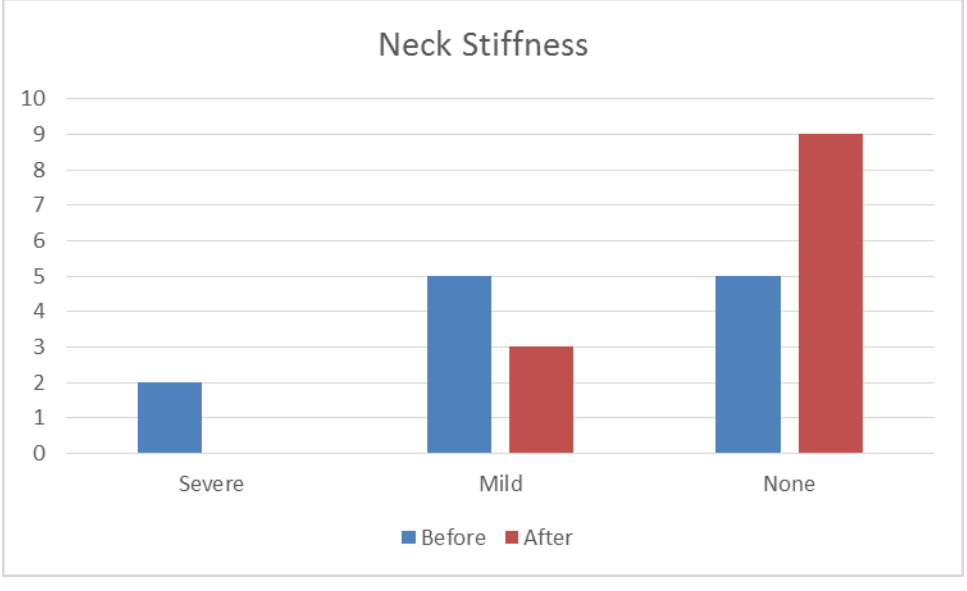

Figure 4. Illustration showing difference in neck stiffness severity before (Blue) and after (Red) implants removal.

DISCUSSION

Many studies have evaluated the functional outcomes of the different surgical techniques in the treatment of odontoid fractures.[19,26] However, there are limited studies assessing the temporary fixation.[10,23]

We focused on type-II fracture, because the natural history of type-I and type-III fractures showed good fusion and healing with just rigid neck fixation.[3,17] We think that posterior C1 lateral mass, C2 pedicle, or laminar screw is better than any other option,[18] especially for cases not indicated for odontoid screw. This is because these options can achieve good reduction to displaced odontoid either with open or with closed maneuver; they have easier insertion points; they do not damage the facet joint as the transarticular fixation does; in addition, they can be removed and rotation is restored. This is especially beneficial when we did not manipulate the facet joint or use Resnick's technique[25] in C1 screws application.

Our results in axial rotation angle were nearly similar to other studies; our mean ROM for total atlantoaxial rotation from right to left was 30±8°. Ruf et al.[23] found in their study that the mean ROM was 37, which may be attributed to the earlier assessment done in our study where the patients themselves and the scar of surgery might be the cause, and we used CT scan instead of MRI.

In our study, functional outcome was better after instrumentation removal. Guo et al.[8] in their study showed a greater patient satisfaction and reduced rate of neck stiffness and disability with temporary fixation, which confirm the effectiveness of the nonfusion technique. They attributed these results to the preservation of the range of motion, which enabled 4.8±61.6° of flexion-extension and 25.7±5.5° of rotation of the atlantoaxial joint 3 months after instrumentation removal. Another study by Stulik et al.[28] showed that ROM increased 10–25% after instrumentation removal. This suggests that temporary fixation can effectively reduce the rate of neck stiffness and disability by regaining ROM, which is reflected on the patient satisfaction in the temporary fixation, confirming the effectiveness of this nonfusion technique. Even, in comparison with nonsurgical management, temporary fixation is superior. Guo et al.[9] confirmed this in a study done to evaluate differences in radiologic and functional outcomes between C1-C2 posterior temporary fixation (PTF) and cephalocervicothoracic cast fixation for type-III odontoid fractures.

Although the odontoid screw is a very effective technique in management of odontoid fracture, there are some limitations to this technique, as it is not suitable for all types of fracture and a higher possibility of pseudoarthrosis can reach 21%,[5] in comparison to rigid posterior fixation.

There are some advantages to using the posterior four screws to fix the segment, although 1 or 2 screws are used when anterior screw fixation is performed. Good results were achieved when at least two-thirds of the fracture surface was in contact after reduction. This in turn results in complete transverse section of the fracture gap which may heal with good fusion. Moreover, odontoid screw fixation is not possible in cases of hyperflexion injuries to the odontoid. Especially for this subtype of injury, the posterior screw fixation according to the method of Goel and Harms is a valuable alternative, especially when implant removal is performed to obtain some atlantoaxial rotatory mobility,[23] which is even superior to wire and cable technique. However, in comparison with anterior screw fixation, studies showed that limitation in movement ranged between 4 and 52% with anterior odontoid screws.[21]

The removal of the screw had significantly improved the neck stiffness, and this achieves what the odontoid screw did with better results in terms of fusion. Rezvi et al.[26] in their study showed that the anterior screw is superior to posterior fixation in neck stiffness with the same neck pain, which is better when we removed that permanent fixation. These results were the same as our findings, as the VAS improved significantly (P=0.0033).

Pitzen Tet al.[23] showed that temporary fixation preserved some rotational motion which depends on age and not sex. This matches with our results, as we did not find any difference related to sex, but the fusion was faster with younger patients in comparison to older ones. Additionally, Molinari et al.[20] found poor results in geriatric patients even with rigid posterior fixation. All our cases were posttraumatic, so surgeries were done shortly after trauma. Moreover, the earlier the surgery was done, the better the results were, in particular the fusion and healing of the odontoid fracture.[27] Another important issue regarding instrumentation removal is that there was no statistical difference related to the timing of instrumentation removal, whether after 3 or 6 months in relation to ROM restored. This was also demonstrated by Ruf et el.[23] in their study.

The limitations of our study were the short follow-up period including the early dynamic CT scan to assess the axial rotation and the considerable limited number of cases. Further studies with calculation after a longer follow-up period and physical therapy are recommended.

CONCLUSION

We believe that posterior atlantoaxial temporary fixation is a good salvage approach in dealing with odontoid fracture, especially when anterior odontoid screw is contraindicated. By regaining partial ROM, the functional outcome of the patients improved.

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الملخص العربي

التثبيت المؤقت الخلفي دون التحام لكسور الفقرتين الأولى والثانية عنقية الحديثة

البيانات الخلفيه: تقنيات الإلتحام الخلفي هي العلاج شائع الاستخدام للكسر السني. لكن هذا يرتبط عادة بالحدود في نطاق الحركة خاصة نطاق دوران الرقبة. يمكن أن توفر تقنية التثبيت المؤقت الخلفي الفقرتين الأولى والثانية عنقية نطاق الحركة للمفصل اللفظي بعد شفاء الكسر السني.

الغرض: لتقييم النتائج السريرية والإشعاعية لتقنية التثبيت المؤقت الخلفي الفقرتين الأولى والثانية عنقية في علاج كسر جديد سني.

تصميم الدراسة: إنها دراسة بأثر رجعي مع التقييم السريري والإشعاعي قبل وبعد إزالة الأعمدة والمسامير.

المرضي والطرق: اثنتا عشر مريضا الذين خضعوا لتثبيت الخلفية الفقرتين الأولى والثانية عنقية مؤقتا من كسر سني حصل التئام الكسر والحركة المستعادة من المفصل. يتراوح العمر بين 15-43 سنة. جميع الحالات كانت بعد الصدمة. الكسر كان منزلق في ثمانية مرضى وأربع حالات كان الكسر في المكان دون أي تزحلق. كان اثنان فقط من المرضى يعانون من عجز عصبي جزئي ما قبل الجراحة.

النتائج: وقد لوحظت نتائج أفضل بكثير في التثبيت المؤقت لدرجة القياس التناظرية البصرية لألم الرقبة. أظهرت النتيجة الإشعاعية استعادة جزئية للدوران بعد إزالة الأجهزة.

الاستنتاج: يعد التثبيت المؤقت الفقرتين الأولى والثانية عنقية طريقة عملية للغاية في علاج الكسر السني. مع إضافة استعادة الحركة الوظيفية بعد إزالة الأجهزة.