Cervical Hooks for Atlanto-Axial Posterior Cervical Fusion

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Abstract

Introduction: Treatment of atlantoaxial instability is predominantly surgical aiming at stabilization, bony union, improvement of pain and neurological status and restoration of normal anatomy of atlantoaxial joint.

Purpose: The present study was designed to determine the surgical yield of cervical C1-C2 fixation by implantation of C1-C2 laminar hook systems via posterior approach for the treatment of patients with C1-C2 instability.

Patients and Methods: The present study included 20 patients; assigned for C1-C2 fusion for non-neoplastic disease; diagnosis and inclusion was confirmed by magnetic resonance imaging (MRI). The applied technique for C1-C2 hook fixation was conducted, using either iliac crest or artificial bone graft. Postoperative bracing (firm collar) was applied for 8-12 weeks. Outcome Measures included radiological evaluation of successful bone fusion, neurological evaluation using the American Spinal Injury Association (ASIA) motor score, neck and arm pain scoring, neck disability index (NDI) and the functional independence measure (FIM) presented as total motor score. Evaluations were conducted preoperatively and at end of follow-up period of at least 6 months.

Results: The study included 11 patients with odontoid fracture, 3 transverse atlantal ligament injuries, 4 as odontoideum and 2 had rheumatoid C1-C2 instability. Preoperative neurological evaluation detected 8 patients were ASIA grade B, 7 were ASIA grade C and 5 patients were ASIA grade D. All surgeries were conducted smoothly without intraoperative complications and an autogenous iliac crest graft was applied in 18 patients, while artificial bone grafts were used in 2 patients. Radiological examinations conducted at end of follow-up period at least 6 months showed evidence of fusion in 65%. Postoperative clinical evaluation revealed significant improvement of neurological ASIA grading and 35% showed complete recovery without motor or sensory deficit. Both pain and neck disability scores was decreased postoperatively compared to preoperative scores. Postoperative total FMI motor power scoring was higher compared to preoperative measures.

Conclusion: Posterior C1-C2 fixation using hooks system is technically simple to apply and can be done safely without concomitant intra-or postoperative complications. High success rates in obtaining fusion and significant improvement at the end of follow-up with high quality-of-life scores make this method of posterior fixation and fusion an optimal surgical modality for higher cervical spine instability which can be executed without any risk of vertebral injury.


Introduction

TRAUMA is one of the major causes of instability of the high cervical spine. In addition, C1-2 intervertebral level of the spine roughly corresponds to the cervicomedullary junction; therefore, correction of instability is desirable to avoid the potential risk of serious neurological sequelae [1].

The atlantoaxial complex, bearing the weight of the head and the atlantoaxial joint, is responsible for most of the rotation of the head and neck. In normal conditions this complex is very strong in spite of its high mobility. However, atlantoaxial instability generally needs to be fixed by surgical intervention in order to create a strong but immobile structure when it occurs [2].

Treatment of atlantoaxial instability is predominantly surgical which aims at stabilization, bony union, improvement of pain and neurological status and restoration of normal anatomy of atlantoaxial joint [3].

Various surgical techniques such as interlaminar clamp, interspinous wiring, have been currently employed to correct the instability of the atlantoaxial complex or occipitocervical junction caused by numerous traumatic and non-traumatic conditions. Biomechanical experiments have shown
these techniques provide excellent antero-posterior stability. However, the rotational movement has been less successful [4].

Recently, transarticular and transpedicular screws fixation have been widely used in stabilizing the cervical column. In spite of the advantage conferred by transpedicular screw fixation in the cervical column, controversy exists regarding its potential risks. Incorrect insertion of pedicle screws can cause damage to adjacent vital structures such as the spinal cord, nerve roots, cranial nerves, and vertebral arteries. Clinically, iatrogenic injury to the vertebral artery during an approach to the atlantoaxial region is rare, but has a potential harmful sequel [4].

Although the posterior wiring techniques and other modifying procedures are most commonly used, nonunion rates vary from 3% to 25%. Additionally, the sublaminar wiring technique carries the potential risk of spinal cord injury from the introduction of wires into the spinal canal [5].

Laminar clamp systems, such as Halifax clamps (Apofix, SofamorDanek), avoid the passage of sublaminar wires and do not have the risks of wire breakage or pull-out, but tend to be dislocated rather easily by rotatory movement of C 1-2, so require grooving of the C-1 and C-2 laminae [6].

C1 and C2 hooks can be interconnected with a transverse connector, thereby reinforcing the stability of the construct against rotational forces. This construct provides adequate stability for fusion if the posterior elements are intact [2].

**Aim of the work:**

The present study was designed to determine the surgical yield of C 1-C2 fixation by implantation of C1-C2 laminar hook systems via posterior approach for the treatment of patients with C1-C2 instability. This technique is much more safer than using screws. We will present our experience with the C1-C2 claw procedure and its implication on outcome.

**Patients and Methods**

The present prospective study was conducted at the Department of Neurosurgery, Cairo University to allow 6-months follow-up for the last case operated upon.

The study included 20 patients assigned for C1-C2 fusion for non-neoplastic disease; diagnosis and inclusion will be confirmed by MR imaging.

**Population of study and disease condition:**

Patients with C1-C2 instability was selected and planned to perform pre-operative MRI-cervical spine and to be fixed with C1-C2 hooks (clamps) and bone graft and followed-up for evaluation of successful bone fusion, non-union or loosening of the clamp and neurological evaluation for improvement or development of new neurological manifestations.

**Inclusion criteria:**

The study included patients with reducible odontoid fracture, transverse atlantal ligament injury, os odontoideum or rheumatoid C1-C2 instability with:

- Age above 12 years.
- Both sexes.
- Fully conscious and well oriented.
- Radiological evidence of Atlanto Dental Interval of >3mm.

**Exclusion criteria:**

- Whiplash syndrome.
- Systemic infection.
- Metabolic bone disease.
- Active malignancy.
- Psychiatric disease.

The applied technique for C1-C2 hook fixation was conducted according to Holness et al., using either iliac crest or autogenic bone graft. Postoperative bracing (firm collar) was applied for 8-12 weeks. Outcome measures included radiological evaluation of successful bone fusion, neurological evaluation using the American Spinal Injury Association (ASIA) motor score, neck and arm pain scoring, neck disability index (NDI) and the functional independence measure (FIM) presented as total motor score. Evaluations will be conducted preoperatively and at end of follow-up [7].

**Evaluation:**

Each patient was evaluated clinically and radiologically with X-rays of the cervical spine in lateral projection and open mouth view in antero-posterior projection. The diagnosis and inclusion was confirmed by MR imaging. The follow-up X-ray was done immediate postoperative and at 6 months.

**Intubation:**

Preoperative fiberoptic intubation is advocated.
Position:

The patient was positioned prone with head in three-pin fixation with flexed cervical spine to increase the space between the posterior arch of C1 and the base of the skull posterior to the foramen magnum, so as to facilitate the passage of the clamp.

Traction may be used to restore anatomic alignment, resulting, therefore, in a technically simpler procedure.

Alignment:

Final positioning is performed using real-time fluoroscopy to verify the alignment of the atlantoaxial complex.

Incision:

The midline was marked; a longitudinal skin incision and superficial dissection were performed with meticulous hemostasis. The nuchal ligament being not always obvious or straight, it could be identified depending on the orientation of the paraspinous muscle fibers; trapezius muscle fibers almost horizontal in the lower cervical spine and becomes more oblique in the upper cervical spine to converge on the nuchal ligament.

Deep dissection was maintained in the relatively avascular nuchal ligament to obtain dry operative field with minimal blood loss and shorter operative time.

Straight, self-retaining retractors were used to retract the subcutaneous tissues to allow dissection of the paraspinous muscles off of the spinous processes and laminae.

Exposure of the posterior upper cervical spine and cranio-cervical junction (C1-C3) was then accomplished in the usual manner.

During dissection of spinous processes and laminae, the interspinous muscles and ligaments above and below the area of interest were tried to be kept intact especially in traumatic injuries in which flexion was contributing mechanism of injury.

Also, meticulous dissection was conducted to avoid injury of the interspinous ligament and muscles at a level above the fusion to avoid the potential for postoperative kyphosis.

Moreover, the bifid tubercles of the spinous process present an uneven surface and are difficult to dissect cleanly with an elevator. For dissection of the tips of the spinous processes; scalpel or the electrosurgery knife was used, then a Cobb elevator was used to retract the paraspinal muscles laterally, and the remainder of the spinous process and lamina were dissected sub-periosteally.

Two Cobb elevators were used; one to retract the paraspinal muscles and to place their fibers on tension and the other to dissect the fibers off the bone.

The subperiosteal dissection was conducted from the occiput to the mid cervical spine.

The posterior elements of C1 and C2 were cleared off from all soft tissues at least 15mm to each side of the midline.

The upper hooks were inserted followed by the lower hooks to be used for widening of the interlaminar space of C1-C2 by delicate rising of the spinous process of C1, were inserted carefully and rods placed over them and then compressed bilaterally. After preparation of the implant bed, choice of suitable hooks size the cranial hook is placed by using the hook holding forceps.

After mild lamina and flavum resection a caudal hook is inserted and the rod is positioned.

Iliac crest bone graft was harvested, decorticated, was then shaped to fit the interlaminar space of C1-C2, similarly the implant site of C1 and C2 laminae is decorticated, the bone graft is applied between C1 C2 lamina and secured in place with prolene sutures wrapped in a figure 8 manner between head of the hooks tightened for 3 to 4 rounds in each direction.

After meticulous haemostasis, wound is closed in layer with subfacial drain if needed.

After treatment:

- Philadelphia collar was worn for 8 to 12 weeks.
- The patient was permitted to sit with support and collar from the first post-operative day and onwards.
- The drain was removed after 48 hours and wound inspected on the third post-operative day.
- Suture removal and discharge will be done on the tenth and twelfth postoperative day.

Follow-up:

The patients were evaluated subjectively for the severity of pain and objectively to see for improvement in neurological status. Radiological evaluation included antero-posterior and lateral X-rays to evaluate bony fusion. The patients were
evaluated to see for any complications related to the above said surgical procedure.

Possible risk:
- Non-union.
- Loosing of the clamp.
- Neurological deficit.

Outcome measures:
1- Evaluation of successful bone fusion: Defined as the absence of C1-C2 movement on lateral flexion-extension radiographs and continuity of trabecular bone formation between C1 and C2 across the graft and disappearance of spine instability.

2- Neurological evaluation: Using the American Spinal Injury Association (ASIA) motor score conducted at admission (baseline ASIA motor score) and last clinical visit (follow-up ASIA motor score).

Table (1): ASIA impairment scale.

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<tr>
<td>A Complete lesion</td>
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<td>B Incomplete sensory preservation</td>
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<tr>
<td>C Incomplete motor preservation ≥ grade 3</td>
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<tr>
<td>D Incomplete motor preservation &lt; grade 3</td>
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<td>E Normal neurological function</td>
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3- Neck and arm pain scoring: Using the 10-point visual analogue scale with 0=no pain and 10=severe pain; baseline and follow-up pain scoring were recorded.

4- Neck disability index (NDI): It is a questionnaire comprised 10 single items related to activities of daily living; each item has 6 categories with 0=no problem and 5=maximum problem; baseline and follow-up NDI scorings were recorded.

5- The functional independence measure (FIM): Scale is a 13-item scale of degree of independence in performing physical tasks. Each task was given a score ranging from 1 (total assistance required) to 7 (complete independence). The total motor scale is the sum of the self-care, sphincter, mobility, and locomotion scores [8].

Results

The study included 20 patients, 13 males and 7 females.

Age distribution:
Their age ranges between 13 and 55 years with a mean age of 34.4 years ± S.D 12.11.

The highest percentage of cases was in the 4th decade (40%).

Sex distribution:
Male to female was 65% to 35% of the total number of cases with a ratio of 1.85:1.

In spite of male predominance, there was no significant difference in the prognosis or outcome between males and females.

Cause of instability:
The cause of instability was fracture of the odontoid process in 11 cases (55%), transverse atlantal ligament (TAL) injury in 4 cases (20%), os odontoidum in 3 cases (15%), and rheumatoid C1-C2 instability in 2 cases (10%).

Fig. (1): Age distribution.

Fig. (2): Cause of instability (pie chart).
The mean duration of symptoms was 2 days; range: 3 hours (traumatic cases) to 4 months (rheumatoid) preoperative neurological evaluation.

All patients complained of posterior cervical pain with variable degrees of radiation to the occipital region. Neck and arm pain (VAS scale) preoperative scores (6.8 ± 1.19 SD), Neck disability index (NDI) preoperative scores (37.55 ± 8.99 SD).

Other manifestations include 25% had paraesthesia, 35% mild hypoesthesia, 40% marked hypoesthesia, 65% have retention (mainly traumatic group), 20% was continent, 15% have precipitancy.

8 patients were classified as ASIA grade B (40%), 5 patients were ASIA grade C (25%) and 7 patients were ASIA grade D (35%).

Preoperative X-ray was diagnostic in most cases, missed 2 cases of odontoid fracture but we proceeded for CT because of symptomatic neck pain and severity of neck trauma, X-ray was suspicious in only 3 cases that was further confirmed with CT cervical and which was very helpful particularly the coronal and sagittal reconstruction views in detecting type of odontoid fracture (type II in 7 cases, type III in 4 cases), also the MRI was superior in detecting TAL injury.

CT was the most time effective, diagnostic and usually done in traumatic cases with significant head injury as all of them will perform CT brain in the same sitting.

All surgeries were conducted smoothly without intraoperative complications and an autogenous iliac crest graft was applied in 18 patients, while artificial bone grafts were used in 2 patients.

The mean duration of the procedure was 100min (range 80-150min) and the average estimated blood loss was 100ml (range 50-300ml).

There were no spinal cord injuries due to hook placement under the lamina.

No vascular or neurological complications were noted.

Radiological examinations conducted at end of follow-up period; range: 6-9 months showed evidence of fusion, defined as the absence of C1-C2 movement on lateral flexion-extension radiographs and continuity of trabecular bone formation between C1 and C2 across the graft and disappearance of spine instability.

Postoperative X-rays and CT detected proper reduction and alignment of C1 C2, there was evidence of bone fusion in 13 cases (65%), while the rest of cases showed proper hooks in place, doing well clinically, no movement on dynamics, probably need to be further followed radiographically to ensure bone fusion.

Three cases showed oblique position of the hooks on one side relatively to the contralateral side with no affection on reduction or alignment of C1 C2.

Postoperative clinical evaluation revealed significant improvement of neurological ASIA grading and 7 patients (35%) showed complete recovery without motor or sensory deficit and 7 patients (35%) had ASIA grade C and 6 patient (30%) ASIA grade C with persistent upper limb weakness and exaggerated reflexes.

Neck and arm pain (VAS scale) showed significant decrease postoperatively (2.75 ± 2.34 SD) compared to preoperative scores (6.8 ± 1.19 SD), neck disability index (NDI) showed significant decrease postoperatively (23.6 ± 12.21 SD) compared to preoperative scores (37.55 ± 8.99 SD).
Postoperative total FIM motor power scoring (57.6) was significantly higher compared to preoperative measures (26.8).

Satisfactory stabilization and reduction was achieved in all patients.

Plain radiographs during follow-up showed no change in hooks position or loss of reduction in any patient when compared with the postoperative radiographs, (the 3 cases of unilateral oblique position of the hooks were in place as immediate post and fused).

Overall, no instrument failures occurred in any patient.

Only 7 cases (35%) still shows no evidence of fusion yet they are stable, reduced, with satisfactory clinical improvement and needs to be further followed up radiography to ensure fusion, besides the clinical follow-up.

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<th>Table (2): Postoperative neurological and functional scores recorded at the end of follow-up period compared to preoperative scores.</th>
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<td><strong>Preoperative</strong></td>
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<td>ASIA grade:</td>
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<tr>
<td>VAS pain score</td>
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<td>FMI score</td>
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According to Frankel grading system above, 6 patients has Frankel grade C (30%).

Seven patients has Frankel grade D (35%), and 7 patients has Frankel grade E (35%).

**Discussion**

Traumatic instability of the upper cervical spine, a common type of injury, includes fracture or dislocation of the spine, as well as ligament damage. It often causes damage to the spinal cord or nerve root. Therapeutic options include decompression of the neural elements, reconstructing or recovering the normal anatomical alignment of the spine, which leads to immediate stability [9].

Although surgery is the choice of most doctors, there is still no agreement on many correlative factors, such as deciding operation time, surgical approach, sequence/level, internal fixator, and dealing with concomitant local pathological situations (traumatic disc herniation/damage, locked-facet dislocation). In addition, the outcomes of its prognosis and evaluation show considerable differences. Another issue is whether an anterior or posterior approach to reconstruction is the better option for those patients who do not need a particular surgical approach or sequence, due to general or local pathological conditions [10].

Jia et al., compared the outcome after 1.8 years follow-up of their series of traumatic upper cervical instability managed conservatively or surgically and found that according to JOA (Japanese orthopedic association score) standard for evaluation, the rate of improvement was 42.5% and 87.0% for conservative treatment and operation respectively and concluded that traumatic upper cervical unsteadiness should be diagnosed and treated early and if the upper cervical vertebra being completely
fixed, the function of cervical vertebra to maximum extent could be reserved [11].

The present study included 20 patients with C1-C2 instability attributed to varied causes, mostly (55%) due to odontoid fracture transverse atlantal ligament injury in (20%), osodontoidum (15%), and rheumatoid C1-C2 instability (10%).

Such figure for the frequency of odontoid fracture goes in hand with Mohamed Lotfy et al., (64.3%) in 2008 described the fixation of 14 patients with atlantoaxial instability with C1 C2 hooks [12], and to some extent goes with Lomoschitz et al., who described the patterns of atlantoaxial fractures in a population of consecutive patients and found a large proportion of these patients (74%) had odontoid fractures [13].

**Age and sex distribution:**

The age of the patients included in the study ranges between 13 and 55 years with a mean age of 34.4 years ±S.D 12.11. This goes with Bohlman et al., who studied 69 patients had involvement of the atlantoaxial joint. More than half of the patients were 21 to 50 years old. Our results as also a review of literature, suggest that no age is exempt from this problem [14].

65% of the patients included in the study were males, while 35% were females.

This goes with Haid RW and others who studied atlantoaxial instability in 75 consecutive operations, composed of 43 men (57%) and 32 women (43%), with a mean age of 44 years ranging 8 to 76 [18].

All studied cases passed smooth intra- and postoperative courses and throughout follow-up period for a duration of at least 6 months.

**Bony union and perioperative complications:**

All cases had no new neurological manifestations, non-union or loosening of the clamp. However, 13 cases (65%) showed evidence of fusion in the follow-up images.

While the remaining 7 cases are reduced, stable in the dynamic views and need further follow-up to ensure fusion in the subsequent radiographs.

Some authors have contended that conventional radiographs may underestimate the degree of fusion. The reason for this is believed to be that premineralized osteoid may be functionally fused but may nevertheless appear radiolucent on conventional radiographs. The calcification of osteoid typically takes many months to complete. As a general rule, it is accepted that at least 6 to 9 months from the time of surgery are necessary for the development of solid inter-segmental fusion to be seen radiographically [16].

These results were superior to that reported in earlier studies; Statham et al., reported that complications occurred in 14 of 45 patients undergoing atlantoaxial arthrodesis; in 10 patients, one of the screws loosened, and in 4 patients, one of the clamps disengaged; additional operations to achieve bone fusion were required in 9 patients (20%), [17].

Also, Agrillo et al., treated four Anderson II fractures by posterior arthrodesis with Halifax clamps and bilateral "H" shaped bone-grafts obtained from the iliac crest and reported one case treated without fusion due to the loosening of one clamp, while in the other cases no post-operative neurological complications appeared and non malunion or nonunion occurred at follow-up, [18].

However, the obtained results were less than that obtained with Huang and Chen, who reported solid atlantoaxial arthrodeses in all (100%) of the 32 patients after average of 84.5 days of halo immobilization, indicating atlantoaxial arthrodeses can be reasonably anticipated when Halifax interlaminar clamps with autogenous iliac bone grafting are reinforced by halo vest immobilization for 3 months [19].

The obtained results were less than that with Mohamed Lotfy et al., 2008. Who reported solid fusion in all 14 cases with no loosening or non union and with Kontautas et al., who treated 6 patients with odontoid fractures with ≤5mm displacement of fragments and 7 patients with >5mm displacement of fragments with immediate C1-C2 posterior fusion and reported that all patients had a solid fusion and concluded that posterior fusion is the treatment of choice for irreducible odontoid fractures [1].

Nekrasov et al., evaluated the outcome of surgical management of 41 patients with fractures of the odontoid of the C2 vertebra using posterior spinal fusion of the C1-C2 vertebrae (Halifax braces) alone and reported that the effect of reposition and stabilization was achieved and the prehospital pain syndrome and neurological deficit virtually entirely regressed [20].

Toohey et al., reviewed 18 cases of pseudarthrosis after attempted anterior cervical discectomy and fusion with tricortical iliac crest autograft using the Smith-Robinson method; all cases were
subsequently treated with posterior fusion using cancellous iliac autograft and fixation with Halifax clamps and all cases showed radiographic union at the 6-month follow-up with no complications related to the application of the device [21].

In support of the choice of posterior approach, Auerbach et al., presented a case of subacute odontoid fracture in a patient with osteopetrosis operated upon with posterior cervical arthrodesis; osteopetrosis is a group of skeletal dysplasias characterized by dysfunction of the osteoclast cells, impaired resorption of bones, and poor bone remodeling. The patient performed a successful posterior cervical arthrodesis and at 2 years, a stable fixation was obtained with only mild postoperative limitation in neck range of motion [22].

Postoperative clinical evaluation revealed significant improvement of neurological ASIA grading in all patients and 7 patients (35%) showed complete recovery without motor or sensory deficit and both pain, and the neck disability scores showed significant decrease postoperatively compared to preoperative scores with significantly higher postoperative total FMI motor power scoring compared to preoperative measures.

These data go in hand with Tokuhashi et al., treated 11 patients with Halifax clamp for atlantoaxial instability and the results showed that this technique was effective in strengthening the rotatory stability of the atlantoaxial fixation and was considered useful for atlantoaxial posterior stabilization and in all patients, occipital pain, neck pain, and neural deficit improved, and bony fusion with no correction loss was shown on radiography with no vascular or neural complications or instrumentation failures [23].

Cao et al., carried out a functional assessment during follow-up, by adopting the JOA and ASIA neurological assessments and functional grades after subaxial spinal fixation using Halifax interlaminar clamps and reported significant improvement compared to preoperative scores and for incomplete SCI, the average ASIA neurological function scale was improved by 1–2 levels [10].

Mohamed Lotfy et al., had superior results, revealed significant improvement of neurological ASIA grading and 12 patients (85.7%) showed complete recovery without motor or sensory deficit and both pain and neck disability scores showed significant decrease postoperatively compared to preoperative scores [12].

Different methods of fixation have been described and used in the management of patients with C1-C2 instability, but each has its shortcomings and defects.

The posterior wiring techniques, such as the Brooks-Jenkins or modified Gallie approach by Dickman, are technically simple but have been associated with high non-fusion rates and require a postoperative rigid externalorthosis.

The Gallie and Brooks technique carries a neurological risk when sublaminar wires are passed under the C1 arch.

When one looks carefully and critically at why posterior wiring techniques fail, it becomes clear that the integrity of these constructs is very dependent on a piece of bone graft wedged between the posterior elements of C1-C2. If the graft collapses or slips posteriorly, the wires loosen, translation occurs, and fixation fails. To avoid this problem, we do not wedge bone between C1 and C2. We use hooks to achieve firm approximation of the posterior elements of C1-C2 and lay down bone laterally on either side of the midline.

The transarticular screw fixation technique led to significant improvements in fusion rates. This technique requires reduction of C1 on C2 before screw placement. Achieving the proper placement of the screws and avoiding injury to the vertebral artery are technically demanding procedures. Additionally, proper allowance of the drill whilst accessing the insertion point on C2 can be restricted in some cases by the patient’s osseous axial anatomy, e.g., pronounced thoracic kyphosis. Screw placement is also difficult in obese patients.

The use of transarticular screw fixation requires high technical expertise of the surgeon. Approximately 20% of patients requiring atlantoaxial fusion display anatomic variations in the course of the vertebral artery and in the osseous anatomy, at least on one side, precluding screw placement.

However, the use of transarticular screws is still not suitable for some patients, such as those patients who were reduced unsatisfactory, the presence of a high-riding VA, or failure to successfully insert the screws during surgery. Recently, several authors have tried using a navigation system for C1-C2 transarticular screw fixation. However, the possibility of a VA injury still exits, [24].

Transpedicular screw and rod fixation is another useful technique for reconstruction of the cervical spine. This technique provides immediate rigid fixation, a high fusion rate and intraoperative reduction. Also, it is applicable to both obese and
kyphotic patients. But, a small C2 pedicle or the medial location of the VA may preclude safe placement of the C2 pedicle screw. Thus, it has been generally recommended that insertion of the screw should be abandoned if the isthmus height is too narrow. However, there were many trials of screw insertion into the narrowed isthmus or pedicle, even though the patient had bilateral high-riding VAs. The safest trajectory of the C1-C2 transarticular screw fixation was at the most medial and posterior part of the isthmus of C2. And, if a surgeon is well experiential with this technique for inserting a screw exactly on this trajectory, it would be possible to insert screws bilaterally and provide rigid fixation, even in patients with unilaterial high-riding VAs. A C2 pedicle screw was placed with a diameter of 3.5mm along the superomedial portion of the pedicle [25].

There are several advantages to a translaminar screw technique in the treatment of C1-C2 instability over other techniques, which include little risk of VA injury and unconstrained screw placement even with variations in the anatomy of C2.

Fixation is technically simpler but requires intact posterior elements, and proper thickness of the laminae to accommodate the screws.

The technique described by Goel et al., in which atlantoaxial fusion is attained through the use of C1 lateral mass screws and converging C2 pars screws is technically demanding, and sometime it is not suitable for placement of C1 pedicle screws when the screw trajectories is broken and when anatomic anomalies are present. Anatomic anomalies, such as anomalous VA or ICA, anomalous posterior arch, and the presence of a lateral mass in the atlas, have been reported. Sometimes a broken C1 pedicle screw trajectory occurs, especially for surgeons without much experience with C1 screw placement. To address these problems, Tan M. et al., combined the use of C1 laminar hooks with transarticular screws to treat an unstable bursting atlantal fracture and obtained satisfactory clinical result, [26].

Posterior interlaminar clamps can be used if the C1-C2 laminae are intact. Without a transverse connector, laminar clamps biomechanically provide reliable stability with flexion and extension maneuvers. However, the clamps are not as effective as in any other technique involving posterior screws with or without wires in rotational motion. Post-operative immobilization for at least 3 months is also recommended with Halifax interlaminar systems [27].

We presented twenty patients treated by C1-C2 claws with interlaminar bone graft. This technique is superior to wiring techniques mainly because there is no need for a halo-vest application. All the patients used a cervical collar after the surgery and the strength of the construct was adequate.

The transverse connector may reinforces the stability of the construct against rotational forces as stated by Hakan et al., [2].

This study describes a method of C1-C2 fixation that uses a hook system, which is simple and safe. Reduction of atlantoaxial dislocation can be achieved during surgery for patients with poor reduction; additionally, the fusion rate is improved because compression of the bone graft is considered to be a positive factor for fusion.

In our cases the chance of pseudarthrosis was not high for the following reasons: The bone bed was carefully prepared and a modified block bone graft was inserted between the C1 posterior arch and the C2 lamina to restrict extension motion, and it was compressed during surgery. Furthermore, the patients were mobilized in a Philadelphia collar postoperation for 2-3 months. In addition, there were only 20 patients in our group; the rate of nonunion needs to be studied in a large clinical series.

The possibility of vertebral artery damage is nearly zero with this technique. The major disadvantage of this technique is the need for intact posterior bony elements, but it is still a simple atlantoaxial posterior structure fixation method.

There were no spinal cord and VA injuries during surgery and no spinal cord or nerve deterioration after surgery. This indicates that the operation is safe. According to preoperative and postoperative Frankel grades, these clinical results confirm that the use of bilateral C1 C2 hooks fixation is safe, provides good biomechanical stability, and can improve the patient's neurological function.

Drawbacks:

The major disadvantage of this technique is the need for intact posterior bony elements. However, this technique is still a two-point fixation method, and the biomechanical strength is lower than that of three-point fixation methods, such as transarticular screws combined with Gallie, so a neck collar is needed to enhance stability after surgery.

The contraindications of this technique include congenital spinal stenosis of C1-C2, failure of C1-
C2 reduction, and absence (e.g. after previous laminectomy) or fractures of the C1 posterior arc.

The premise for using this method is that the space between the dura sac and the C1 posterior arc is large enough to accommodate the C1 hook. Use of this technique is indicated only for C1-C2 dislocation due to trauma, congenital malformations or RA, failure of the Magerl technique, and the developmental tiny of C1 pedicle that not suitable for Goel technique [28].

In the Halifax technique, a double hook and screw construct stabilizes the laminae of C1 and C2 bilaterally and secures the bilateral interlaminar bone grafts. Initially, this technique was described on a single side only and without the addition of a bone graft with acceptable results. However, when used to stabilize the C1-C2 complex, bilateral clamps with bone grafts have proven to be superior. Biomechanical experiments have shown this technique provides excellent anteroposterior stability. However, the rotational movement has been less successful than either the Brooks-Jenkins or Magerl techniques [29].

In our study, Halifax interlaminar clamps provided excellent antero-posterior stability. The shaped bone graft fitting the C1-C2 interlaminar space was secured with Prolene, providing compression pressure and improving the fusion rate, wrapped around screws decreased the rotational shear force in a similar way to the wires used in the Brooks-Jenkins fusion. Prolene has been found to be non-allergenic, non-pyrogenic and elicits only a slight tissue reaction and non-absorbable.

This technique has no risk of neurovascular injury, unlike sublaminar wiring or transpedicular screws. It is less technically demanding and has good anterio-posterior and rotational stability. Finally, it is one of the most cost-effective technique.

These various fixation techniques provide the surgeon with options to treat atlantoaxial instability with the most appropriate technique depending on patient anatomy, surgical indication, presence of the posterior elements, and surgical ability [29].

Study limitations:

The most obvious is the lack of any non-operative-treatment group with which to compare the results. However, conservative treatment would often be hard to justify, considering the poor clinical condition of the patients already receiving maximal medical therapy.

Although extended period of follow-up more than 6 months at least is required for analysis of the bone fusion of the further 7 cases (35%) that are stable yet not fused on radiography, also for analysis of the rehabilitation and return to work to be included in the final judgment during comparison of these surgical techniques.

Conclusions:

The most common presenting symptoms in the patients included is the study was neck pain and difficulty in movement of neck, variable degrees of quadriparesis.

The most common cause of atlantoaxial instability was odontoid fracture (55% of the patients).

Among the various etiologies, the 4th decade of life had the highest overall prevalence of C1 C2 instability.

The technique of C1 C2 hooks enabled fusion in 65% of patients (may be higher in extended follow-up period).

Postoperative clinical evaluation revealed significant improvement of neurological ASIA grading of all patients and (35%) showed complete recovery without motor or sensory deficit.

No major complication encountered during the said surgical procedure, with no injury to the vertebral artery in any patient, with no new surgery related neurological deficit postoperatively.

The major disadvantage of this technique is the need for intact posterior bony elements, yet it is still a simple atlantoaxial posterior structure fixation method.

In conclusion: Posterior C1-C2 fixation using Halifax clamp system is technically simple to apply and can be done safely without concomitant intra- or postoperative complications. High success rates in obtaining fusion and significant improvement at the end of follow-up with high quality-of-life scores make this method of posterior fixation and fusion an ideal surgical modality for higher cervical spine instability which can be executed without any risk of vertebral injury.

References


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الملخص العربي

الإصابات هي واحدة من الأسباب الرئيسية لعدم الاستقرار في العمود الفقري العنق، بالإضافة إلى ذلك، مستوى الفقرات الأولى والثانية في العمود الفقري يحتمل ترقبًا للأمراض الشبكية وجدوع الدم، وبالتالي تصحيح عدم الاستقرار ينفع المخاطر المحتملة من الاصابات العصبية الخطرة أكثر. وفي بعض الظروف التي يمكن أن تؤدي إلى عدم الاستقرار في الفقرات العنقية (2) تشتمل الإصابات والتهاب المفاصل الروماتويدية، التشوهات العقلية، والالتهاب والأمراض، وارتفاع الأربطة.

العلاج غالباً ما يكون جراحيًا ويهدف إلى تحقيق الاستقرار، والتحام العظام، وتحسين الألم والحالة العصبية واستعادة التشريح الطبيعي.

في هذه الدراسة، استعرضنا 30 مريضاً يعانون من عدم الاستقرار بالقرارات العنقية الأولى والثانية. فماذا يعمل رنين مغناطيسي على الفقرات العنقية لتأكيد التشخيص وتم تثبيت الفقرات العنقية الأولى والثانية باستخدام المشابك الخلفية.

النتائج:
- كان الذكور إلى الإناث 2/3 إلى 1/3 من إجمالي عدد الحالات.
- الكسر العظمي بالقرارات الثانية هو السبب الأساسي لعدم الاستقرار.
- التقييم ما بعد الجراحة أظهر تحسنًا كبيرًا من الحالة العصبية و2/3 من المرضى شفي بالكامل دون عجز حسي أو حرفي وانخفض كل من الألم والرقاقة بعد الجراحة.
- فقد حقق الاستقرار بالقرارات في جميع المرضى والتحام في 2/3 من الحالات بعد 6 أشهر.

بين مختلف السبب، كان استقرار الارتجج هو أعلى معدل لانتشار عدم الاستقرار.

إن تثبيت الفقرات العنقية الأولى والثانية باستخدام المشابك الخلفية يسهل التطبيق من الناحية الفنية ويمكن أن يتم دائمًا دون مضاعفات مصاحبة لذلك، إذ أن ما بعد الجراحة يؤدي للحصول على معدلات نجاح عالية في الاتصال وتحسين كبير في نهاية فترة المتابعة مع جودة الأداء الحيوية، مما يجعل هذا الأسلوب من التثبيت الخلفي طريقاً جراحيًا مثاليًا لحالات عدم الاستقرار بأعلى العمود الفقري العنق.