Occipitocervical Fusion Surgery: Review of Operative Techniques and Results

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Abstract

Objective Varying types of clinicoradiologic presentations at the craniovertebral junction (CVJ) influence the decision process for occipitocervical fusion (OCF) surgery. We discuss the operative techniques and decision-making process in OCF surgery based on our clinical experience and a literature review.

Material and Methods A total of 49 consecutive patients who underwent OCF participated in the study. Sagittal computed tomography images were used to illustrate and measure radiologic parameters. We measured Wackenheim clivus baseline (WCB), clivus-canal angle (CCA), atlantodental distance (ADD), and Powers ratio (PR) in all the patients.

Results Clinical improvement on Nurick grading was recorded in 36 patients. Patients with better preoperative status (Nurick grades 1–3) had better functional outcomes after the surgery ($p = 0.077$). Restoration of WCB, CCA, ADD, and PR parameters following the surgery was noted in 39.2%, 34.6%, 77.4%, and 63.3% of the patients, respectively. Complications included deep wound infections ($n = 2$), pseudoarthrosis ($n = 2$), and deaths ($n = 4$).

Conclusion Conventional wire-based constructs are superseded by more rigid screw-based designs. Odontoidectomy is associated with a high incidence of perioperative complications. The advent of newer implants and reduction techniques around the CVJ has obviated the need for this procedure in most patients.

Keywords

- occipitocervical fusion
- surgical techniques
- atlantoaxial instability

Introduction

Occipitocervical fusion (OCF) is an effective surgical method to treat various craniovertebral junction (CVJ) pathologies (i.e., congenital, traumatic, degenerative, inflammatory, infective, or neoplastic).^{1–5} Compressive myelopathy from mass lesions (inflammatory/neoplastic), basilar invagination, and instability at the occipito-atlanto-axis region are the most common indications for the surgery.^{6,7} Over the past several decades, the fusion techniques have evolved from simpler methods like onlay graft with or without wiring to the more rigid modern fixation modalities.⁸ Prolonged immobilization in a Minerva jacket or a halo vest is rarely performed today as

a result of the rigid fixation achieved from the newer techniques.⁶

Various factors influence the operating surgeon's decision from the preoperative cervical traction to the method of decompression (i.e., anterior, posterior, or circumferential), selection of the appropriate implant, fusion levels, and postoperative immobilization.^{9–13} In addition, the clinicoradiologic presentation of CVJ pathologies is also diverse.^{6,7} The status of the posterior elements and reducibility of the atlantoaxial joint also influences decision making.¹¹ The aim of this study is to share our surgical experiences with OCFs and discuss the operative techniques and factors influencing decision making in OCF surgery based on our findings and a literature review.

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Methods

We performed a retrospective analysis of 49 patients who underwent OCF surgery from 1998 to 2011. Institutional review board approval was obtained before conducting the study. Patient's demographic features, clinical presentation, surgical details, and outcomes were recorded. The outcome was measured by using the Nurick functional grading system.¹⁴

Patient Population

A total of 29 male and 20 female patients with a mean age of 58.1 years (range: 19–85) were included in the study. Patients' diagnoses and indications for OCF are summarized in ►Table 1. The most common presenting symptom was gait instability ($n = 29$). Motor weakness ($n = 21$), numbness ($n = 15$), neck pain ($n = 11$), and lower and cranial nerve involvement (dysphagia $n = 4$, dysarthria $n = 2$, and ocular disturbance $n = 2$) were other presenting features.

Imaging and Occipitocervical Craniometry

Patients were evaluated preoperatively by anteroposterior and lateral radiographs of the CVJ. Flexion-extension views

were also done to assess stability. Computed tomography (CT) was performed to provide more distinct information about bony architecture. Radiologic parameters (►Fig. 1) were measured on CT sagittal images that included Wackenheim clivus baseline (WCB), clivus-canal angle (CCA), atlantodental distance (ADD), and Powers ratio (PR).^{15–18} WCB is a tangent line drawn along the superior surface of clivus. Migration of the dens above or posterior to this line was defined as basilar invagination.¹⁵ CCA is an angle formed by WCB and the posterior vertebral body line. The normal range of CCA is from 180 degrees in extension to 150 degrees in flexion. A CCA angle < 150 degrees was considered abnormal, which indicated ventral spinal cord compression.¹⁶ ADD is the distance from the anterior arch of C1 to the dens. A distance > 3 mm in adults or > 4.5 mm in children was abnormal and labeled as atlantoaxial subluxation.¹⁷ The basion-posterior arch interval (BP) and opisthion-anterior arch interval (OA) were measured. PR (BP/OA) was calculated, and a ratio > 1.0 was considered abnormal, which indicated atlanto-occipital dissociation.¹⁸ Radiographic evaluation of the patients in the postoperative period was performed in the same manner. Fusion was assessed with flexion/extension plain radiographs every 3 months until the 1-year postoperative period. A CT

Table 1 Summary of diagnosis and surgical indications

Diagnosis	No.	Surgical indication	No.
Traumatic			
Acute: Odontoid fracture	3	Compressive myelopathy	3
Hangman fracture	4		
Jefferson fracture	3	Craniocervical instability	8
OC vertical distraction injury	2		
Old: Odontoid fracture	4	Myelopathy and instability	6
Hangman fracture	1		
Rheumatoid arthritis	14	Basilar invagination	2
		Pannus	4
		Basilar invagination and C1–C2 instability	8
Degenerative	6	Severe C1–C2 arthritis with stenosis	1
		C1–C2 instability	3
		Occipito/C1–C2 instability	1
		Anterior clival-craniocervical junction mass	1
Neoplastic: Odontoid osteochondroma	1	Mass lesion	4
Metastasis (lung/breast)	2	Atlantoaxial instability	3
Multiple myeloma	1		
Lymphoma	1		
Congenital: Chiari malformation	2	Basilar invagination	2
Os odontoideum	2	Instability and myelopathy	2
Achondroplasia	1	Foramen magnum stenosis	1
Osteogenesis imperfecta	1	Basilar impression	1
Infection	1	Instability and myelopathy	1

Abbreviation: OC, occipitocervical.

Fig. 1 Radiologic evaluation using midline sagittal computed tomography scan. (A) Wackenheim clivus baseline (WCB). (B) Powers ratio (PR). (C) Atlanto-axial distance (ADD). BP, basion-posterior arch interval; CCA, clivus-canal angle; OA, opisthion-anterior arch interval; PR, Powers ratio.

scan was specifically performed at 6 months to evaluate the craniometric parameters and fusion. Three-dimensional computed angiography was performed in several patients ($n = 31$) to identify the anomalous vertebral artery (VA), especially when atlantoaxial instrumentation was desired.

Surgical Technique

Patients were placed prone with the head secured in three-point Mayfield tongs. Approximately 15 to 20 pounds of weight was attached to the traction unit. A midline incision from theinion to the desired cervical level was made. Soft tissues were reflected off the cervical spine and occiput to identify the bony landmarks and facilitate decompression and instrumentation. Posterior decompression was performed in several patients ($n = 24$). A C1 and/or C2 laminectomy was sufficient to achieve decompression in most cases. Posterior fossa decompression by a suboccipital craniectomy was performed in five patients with substantial basilar invagination (rheumatoid arthritis $n = 2$) and contracted posterior fossa volume (Chiari malformation $n = 2$; achondroplasia $n = 1$). Anterior decompression with odontoidectomy was performed as a separate procedure in 10 patients. In nine of these patients, odontoidectomy preceded to the OCF, and in one patient it was performed after the posterior fusion. The most common indication of the odontoidectomy was ventral cord compression from basilar invagination in rheumatoid arthritis ($n = 5$). ▶Table 2 summarizes the specifics of the implants used, C1–C2 instrumentation, bone graft utilization, extent of the fusion levels, and methods of postoperative immobilization.

C1–C2 instrumentation consisted of C1 lateral mass and C2 pedicle screws/pars screws placement. Lateral mass screws were inserted in the subaxial cervical region to the desired level of the fusion distally. Fixation to the cervical spine was achieved with sublaminar wire in wire-rod constructs. Fixation on the occipital side varied with the type of the implant used. In occipital plate constructs, the site of intended screw

insertion was marked with the use of templates to place the occipital plate contoured with the surface of bone. Bicortical screws were inserted to fix the plate to the occiput, which had deeper purchase in the midline (7–14 mm) than in the paramedian cranium (6 mm). For the “inside-out” screw, an opening was made for the occipital bolt ~1 cm away from the site marked for the actual screw site in the paramedian cranium, and a groove was created connecting the two. The bolt was slid through the groove and secured to the plate-rod system with the nut. When rod-wire constructs were used, for occipital wiring two burr holes at least 1 cm apart were fashioned in the suboccipital bone 2.5 to 3 cm above the foramen magnum. A contoured rod was fixed to the occiput using double-stranded Luque wire passing through burr holes.

In situ fixation was performed in most of the earlier cases. During the later procedures, reduction of occipito-atlanto-axial subluxation was attempted using the cervical rod-screw construct as a lever to control the cervical spine and forcing it against the occiput, manually maintaining the distraction from the traction unit (▶Fig. 2). After assessing the reduction under fluoroscopy, fixation on the occipital side was performed. Specific surgical steps were taken depending on the underlying pathology. A Y-shaped incision over the dura was made to decompress the spinal cord in patients with Chiari malformation. Thick arachnoid membrane dissection and a unilateral tonsillectomy (left in both cases) were required to establish a spontaneous cerebrospinal fluid (CSF) flow. Duroplasty with an allogeneous dural patch was performed in both the patients with Chiari malformation.

Intraoperative somatosensory-evoked potentials and motor-evoked potentials were used to assess the physiologic changes in the brainstem and spinal cord, especially during the instrumentation and reduction maneuvers. Fluoroscopic guidance was used throughout the procedure. Postoperative checks were performed at serial intervals.

Table 2 Summary of surgical techniques

Technique	Method	Specification	No.
Decompression	Anterior	Odontoidectomy	
		Preceded by the fusion	9
		Followed by the fusion	1
	Posterior	Cervical laminectomy (C1–C2)	24
		Suboccipital craniectomy	5
Implants	Modular occipital plate-cervical rod		23
	Occipital screw-cervical rods		
	Inside-out occipital screw		15
	Occipital conventional screws		4
	Malleable rods-wire		3
	Inverted Y-shaped plate screw		2
	Cervical rod-integrated plate		2
C1–C2 instrumentation	C1–C2 fixation ($n = 30$)	C1 sublaminar wiring	4
		C1 lateral mass screws	3
		C2 sublaminar wiring	7
	None ($n = 19$)	C2 pedicle screws	5
		C2 pars screws	13
		C2 translaminar screw	1
Fusion levels	Spanning C1–C2 ($n = 19$)	O–C2	12
		O–C3	14
		O–C4	6
	Incorporating C1–C2 ($n = 30$)	O–C5	9
		O–C6	5
		O–C7	3
Graft options	Autograft ($n = 4$)	Iliac crest autograft	7
	Allograft ($n = 2$)	Cadaveric rib graft	2
	Synthetic ($n = 42$)	DBM and morselized bone	28
	Not known ($n = 1$)	DBM and morselized bone and rhBMP	11
Postoperative immobilization		Soft collar	35
		Philadelphia collar	10
		Halo vest	4

Abbreviations: DBM, demineralized bone matrix; O, occiput; rh-BMP, recombinant human bone morphogenic protein.

Results

Radiologic Results

Basilar invagination was the most common radiologic finding observed in our series (abnormal location of dens in relation to WCB $n = 24$). An abnormal CCA angle > 150 degrees in flexion was recorded in 23 patients. Abnormal values of ADD and PR were observed in 12 and 15 patients, respectively. These parameters were intact in 14 patients. Restoration of WCB, CCA, ADD, and PR parameters following the surgery was noted in 39.2%, 34.6%, 77.4%, and 63.3% of the patients, respectively. Approximately 30.3% of deformities (on the basis of these radiologic parameters) could not be reduced during the surgery. Reduction and restoration of the radiologic

parameters were achieved in a larger number of patients with traumatic lesions compared with patients with non-traumatic lesions ($p = 0.026$). Increased ADD was the most common radiologic finding in patients who underwent odontoidectomy (Fisher exact test; $p = 0.014$).

Clinical Outcome

Fifteen patients had a mild to moderate impairment of functional status on the severity grading (Nurick grades 1–3), whereas the remaining patients ($n = 34$) presented with severe impairment of functional status (Nurick grades 4–5). Following surgery, clinical improvement was recorded in 36 patients, no change in 9 patients, and a worsening of

Fig. 2 Reduction technique for basilar invagination (BI). (A) A 64-year-old male patient with rheumatoid arthritis with extensive disruption of anatomy at the craniovertebral junction. Cervical rod-screw construct is used as a lever to control the cervical spine and pushed toward the occiput maintaining the distraction force. When reduction is confirmed on fluoroscope, fixation on the occipital side is performed. (B) Postoperative X-ray showing near anatomical reduction of the BI and restoration of radiologic parameters.

neurologic symptoms was observed in 3 patients. Patients with better preoperative status (Nurick grades 1–3) had better functional outcomes after the surgery (Fisher exact test; $p = 0.077$). Four patients died in our series. Both the patients with metastasis of the odontoid process died of complications related to the primary malignancy. A 73-year-old woman who underwent OCF for rheumatoid pathology was operated for odontoidectomy due to persistent symptoms at 3 weeks after the first surgery. She died of respiratory failure and septicemic shock following the second procedure. The fourth patient died of unrelated causes.

Fusion Rates and Complications

Deep infection ($n = 3$) was the most common cause of the morbidity. Implant dislodgement was also seen in all three patients: loosening of occipital screws in two patients and loosening of the implant on both sides in one patient. In the patient with implant failure on both sides of the fusion, the whole implant assembly was removed. The other two patients were reoperated for wound lavage and a revision of the occipital screws ($n = 2$). Fusion did not occur in two of the three patients with deep infection. One patient with a superficial wound infection responded well to wound wash and antibiotics. Occipital screw loosening was also observed in another patient without any evidence of infection.

Fig. 3 Occipitocervical fusion for lymphoma of axis bone. (A, B) Sagittal and coronal computed tomography scan of the craniovertebral junction (CVJ) in a 33-year-old man showing extensive destruction of the axis. (C) Magnetic resonance imaging (MRI) shows compression at the cervicomedullary junction resulting from bone debris and neoplastic tissue. (D) Immediate postoperative X-ray of cervical spine showing occipitocervical fusion (OCF) surgery performed with contemporary plate-rod construct. (E) At 4 months after OCF surgery, the patient presents with progressive myelopathic symptoms, and X-ray of the cervical spine reveals the loss of fixation with flexion deformity at the CVJ. (F) MRI shows a substantial cord compression as a result of pseudoarthrosis and kyphotic deformity.

Reinsertion of occipital screws was performed, and fusion (although delayed at 9 months) could then be achieved in this patient. One patient with odontoid lymphoma had implant failure and pseudoarthrosis 4 months after the OCF surgery (—Fig. 3). Adjuvant radiotherapy in the neck for lymphoma may have been a predisposing factor for implant failure and pseudoarthrosis in this patient. Flexion deformity at the CVJ due to loss of fixation resulted in progressive myelopathy in this patient. A revision procedure with the extension of fusion levels was offered to the patient at the last follow-up. One patient complained of hardware prominence. As already mentioned, one patient with persistent myelopathic symptoms was operated on for odontoidectomy. During the early postoperative period, her course was complicated by respiratory failure, and she died of generalized sepsis and multi-organ failure. Except in four patients (two with deep infection, one patient with odontoid lymphoma, and one patient who died of respiratory failure), radiologic fusion was documented in the remainder of the patients (91.8%). —Table 3 summarizes the complications.

Discussion

OCF is an effective method to treat a variety of pathologies at the CVJ. Preoperative assessment and planning is crucial to achieve favorable outcomes from the surgery at such a highly specialized area of the spine.¹⁹ Underlying pathology, condition, and architecture of the occipitocervical spine, status of the posterior elements, reducibility of the lesion, anomalous VA, and radiologic parameters are some of the important factors that influence operative decisions during OCFs.^{6,11,19,20}

Cervical Traction

Superior migration of the odontoid process in basilar invagination is associated with horizontal clivus and craniovertebral deformity, which results in ventral compression at the spinomedullary junction.²¹ To relieve the pressure off the cord and reduce the deformity at the CVJ, several authors have advocated the use of cervical traction in patients with basilar invagination before surgery.^{21–23} Peng et al²² used the Gardner-Wells tong traction several days before the fusion was performed. They could achieve a substantial amount of reduction with the traction alone, and further reduction was attempted with the implant assembly. Ventral decompression obtained from this method rules out the possibility of odon-

toidectomy and avoids the complications of this surgery.^{21,22} In contrast, Goel and Shah²⁴ observed the loss of reduction in patients who underwent fusions after correcting the deformities with cervical traction. We did not routinely use (excluding traumatic lesions) preoperative cervical traction in our patients. However, in two cases with instability of the atlantoaxial complex as a result of odontoidectomy, traction was applied until the OCF was performed. Use of intraoperative cervical traction was almost universal.

Decompression

Before the introduction of anterior decompression by odontoidectomy, foramen magnum decompression along with in situ fixation with pins and wires was the only option available. Unfavorable neurologic outcomes from in situ fusions led to the development of ventral decompression by odontoidectomy.²⁵ Improved functional results from odontoidectomy are also associated with a high incidence of complications. Close proximity to oral bacterial flora makes the procedure prone to postoperative infection. Wound dehiscence, aspiration pneumonia, CSF leakage, and dysphagia are other common complications.²⁶ Tracheostomies performed in patients with lower cranial nerve involvement can also be an additional source of increased morbidity following the odontoidectomy. In our series, one patient who underwent odontoidectomy before the fusion developed septicemia from the infected tracheostomy site; however, the patient responded well to broad-spectrum antibiotics, and the fusion surgery could be performed after several weeks. Another patient, who required odontoidectomy due to progressive neurologic symptoms following OCF, developed respiratory failure following the procedure and died in the early postoperative period. The main indications for odontoidectomy in our patients were either severe basilar invagination in RA ($n = 5$) or ventral compression from the tumor mass ($n = 2$). Anterior decompression is still considered an appropriate option in the latter pathology.²⁷

The evolution of novel reduction techniques and the development of newer implants for OCFs have made decompression of this complex region far easier than before. Goel et al²⁸ described a CVJ realignment method in which a wide resection of the atlantoaxial capsule and distraction of this joint manually along with the placement of a metal spacer reduces the basilar invagination and atlantoaxial (AA) subluxation. Distraction of the AA joint reduced the vertical deformity more efficiently, but the inconsistent correction of the ADD was a major limitation of this method.²⁹ To overcome the shortcomings of the CVJ realignment method, Jian et al³⁰ described an intraoperative distraction technique. However, the reduction of deformities with the distraction-only methods could achieve restoration of ADD in only 85% of the cases. Second, distraction without the spacer also caused resettling in some cases. To achieve more efficient realignment and prevent the loss of reduction, Chandra et al²⁹ devised a new technique called distraction, compression, and extensive reduction (DCER). In this technique, the first step was to insert a metal spacer to distract the joint to correct the basilar invagination. Compression and extension through

Table 3 Complications

Complications	No.
Deep infection	3
Superficial infection	1
Implant loosening	4
Pseudoarthrosis	4
Deaths	4
Hardware prominence	1

C1–C2 and/or occipital screws using a metal spacer as a fulcrum corrected the AA instability and restored the ADD more efficiently (complete reduction in 94% of patients). The application of the recent techniques of reduction has obviated the need for odontoidectomy. We followed the standard policy of anterior decompression by odontoidectomy followed by posterior OCF in several initial cases of this series. With the development of reduction methods and newer implants, we attempted the reduction from the posterior in most of the recent cases. Our method of reduction was similar to DCER, except we never performed the distraction of the AA joint. We relied on distraction forces to reduce the basilar invagination.

Implant Selection

Almost a decade ago, semirigid fixation using a rod and wire construct was the preferred method.^{6,31,32} The need for prolonged postoperative immobilization and the high incidence of dural laceration during sublaminar passage of wires were the biggest drawbacks of this technique.¹¹ Rods and wire constructs are largely superseded now by occipital plate and rod designs. These screw-based constructs are technically demanding procedures; but they offer several advantages over the earlier constructs. The three-column purchase of the cervical screws provides more stiffness to the implant assembly compared with the engagement of only lamina from the wires or hooks.³³ Efficient reduction of the deformities with the use of the rigid constructs is crucial to achieve decompression around the foramen magnum.^{29,30} As with the use of a stronger construct, a lesser number of spinal segments needs to be fixed, which offers a minimal disturbance to the motion of the cervical spine.³⁴

The thickness of the occiput is maximum at the external occipital protuberance, which decreases as we move away from the midline both laterally and inferiorly.³⁵ Occipital screws in the midline have greater pull-out strength, but the plates with only midline screw options have weaker torsional strength than the plates that included both midline and laterally placed screws.³⁶ Therefore, most of the recent occipital plates incorporate the holes for midline as well as lateral screw insertion. Except at the external occipital protuberance, more laterally, the pull-out strength of the unicortical screws is comparable with bicortical screws. Because the contribution of the inner table is minimal, the placement of unicortical screws lowers the risk of intracranial venous penetration.³⁵ However, we generally use the bicortical purchase of occipital screws at our institution. To have an optimal fixation in the thin occipital bone laterally, several of the contemporary screws are also designed to have a larger diameter with a small pitch.³³ Another technique commonly used for the occipital fixation is the “inside-outside” screw fixation method, described earlier. There are several advantages of this technique.^{37,38} Apart from the stronger purchase in the bone, insertion of the screw under direct vision avoids any possible damage to the underlying dural or venous structures.³⁷ Greater pull-out strength due to the larger surface area of fixation is especially more important in pediatric patients, who have a very thin skull, because it

provides stronger purchase in the occiput than is possible with conventional screws.³⁸

Nevertheless, with the availability of contemporary rigid fixation modalities, some authors still prefer conventional methods.³² We initially used more conventional (wire-rod constructs) methods that are mostly contemporary (plate-rod constructs, inside-outside designs) in recent patients. Screw-based rigid fixation allowed efficient reduction of the deformities in our patients. We now use the wire-rod constructs only in patients with very poor quality of bone who would otherwise have a high incidence of failures from the screw-based constructs. A cervical rod-integrated plate is a useful construct in patients with occipital defects due either to some congenital conditions (i.e., Arnold-Chiari malformation) or resulting from the previous extensive suboccipital craniectomy.³³ The fusion rate of 91.8% in the present series is lower than the fusion rate of 94 to 97% from the centers that used contemporary screw-rod or screw-plate constructs.¹⁹ A later finding may be either due to the use of conventional methods of fixation in some patients or inclusion of a wide variety of pathologies including metastatic lesions.

Fusion Levels

Fusion at the CVJ may result in a substantial loss of motion in the cervical spine, and incorporation of each subaxial spine segment would cause an additional loss of ~ 10 degrees per

Fig. 4 Extensive involvement of the cervical spine in a 64-year-old woman with multiple myeloma. (A, B) Sagittal and coronal computed tomography scan of craniovertebral junction showing several osteolytic lesions involving multiple segments of the cervical spine (C2–C6); C4–C6 is a fused segment. (C) Magnetic resonance imaging showing significant compression at the cervicomedullary junction with a diffuse involvement of the cervical spine. (D) Occipitocervical fusion was performed from occiput–C7 levels incorporating the subaxial affected segments.

segment.^{39,40} Thus the decision about the caudal extent of the fusion is also an important issue. Song et al¹¹ reported that the reducibility, status of the posterior elements, and the direction of the surgical approach determine the number of fusion levels. As a result of in situ fixation and the use of conventional implants during the early few cases, inclusion of more levels in fusion was a routine at our institution. More recently, with the advent of very efficient reduction techniques and the use of rigid constructs, the inclusion of the subaxial cervical spine in the fusion is performed only in selected conditions. The extent of pathologic involvement and degenerative changes in the cervical spine are determinants of fusion levels at our institution (►Figs. 4 and 5).

Bone Graft Options

Choosing an appropriate graft option is also a crucial decision. In most patients, we used morselized bone graft mixed with demineralized bone matrix. The role of recombinant human bone morphogenetic protein (rhBMP)-2 for neck fusion is controversial, and having considered the high potential of complications, the Food and Drug Administration has not yet approved the use of rhBMP-2 for fusions in the neck. Lindley et al⁴¹ shared their experiences with the off-label use of rhBMP in pediatric patients who underwent OCF. They

reported a substantial rate of complications (10.4%) in their patients that were associated with the use of rhBMP-2. Except in revision OCFs for patients with active smoking status, we defer to using BMP routinely.

Postoperative Immobilization

Earlier conventional semirigid implants necessitated a more protracted course and required prolonged immobilization with stronger devices like a halo vest. Rigid fixation obtained from the new implant system has obviated the need for such cumbersome methods. Second placement of a halo vest is an invasive method and associated with various complications like pin track infection, loosening, dural puncture, and nerve palsies (abducens, supratrochlear, supraorbital). A soft cervical collar and a Philadelphia collar are appropriate choices in most cases with the use of modern surgical techniques. However, in patients with a very poor quality of bone, extensive loss of bony structure, or in patients with early signs of implant loosening, a halo vest may be a useful alternative to salvage the fusion.

Conclusion

Decision making in OCF is influenced by a diverse clinicoradiologic presentation of the pathologies at the CVJ. Odontoidectomy may be associated with substantial morbidity; therefore, the procedure should be used only in selected conditions like irreducible deformities and tumors causing ventral cord compression. The caudal extent of pathologic involvement and degenerative changes in the subaxial spine are the important determinants of the levels of fusion. Synthetic bone graft substitutes mixed with morselized bone is an appropriate graft option. The use of rh-BMP remains controversial and does not affect overall fusion rates. The reports of life-threatening complications in the literature warn against the liberal use of rh-BMP in OCFs.

Fig. 5 Occipitocervical fusion (OCF) in patients with degenerative cervical spine. (A, B) Radiographs of a 64-year-old woman showing the involvement of the odontoid process by an infective pathology. The patient underwent OCF incorporating the degenerated segments (C4–C5). (C, D) Radiographs of a 55-year-old man showing the posttraumatic instability of the atlantoaxial joint. Fusion was performed involving the degenerated segments (C4–C5).

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