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Operative treatment of unstable injuries of the cervicothoracic junction

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Abstract The authors present their experience in the operative treatment of unstable lesions at the cervicothoracic junction. Ten patients, six men and four women, underwent operative procedures at the cervicothoracic junction (C7-T1) between 1990 and 1997. Six patients had sustained fracture-dislocations, three patients had metastases and one patient had a primary malignant lesion. All the patients had significant cervical pain and neurologic deficit. The spinal cord and nerves were decompressed in all cases. Posterior stabilization was accomplished using various types of implants including hooks, wires and rods. Anteriorly, the spine was stabilized with plates and screws. Partial or complete vertebrectomy was performed in five cases and a titanium cylinder or an iliac autograft replaced the vertebral body. Five patients were submitted to a posterior operation only, and the other five to bilateral procedures. In four of these a one-stage operation was performed and in the last case a two-stage procedure. The anatomic and biomechanical characteristics of the cervicothoracic junction require a precise pre-operative analysis of the local anatomy and the selection of the proper implants for anterior and posterior stabilization.

Key words Spine · Cervicothoracic junction · Instability · Operative treatment

Introduction

Instability of the cervicothoracic junction presents a severe clinical problem. Common causes include trauma, extensive laminectomies and destruction of the vertebral body by neoplasm.

Instability between C7 and T1 can lead to an increased kyphosis with subsequent narrowing of the spinal canal and damaging of the spinal cord. The management goals are immediate stabilization, maintenance of anatomic alignment and early rehabilitation. Many authors [2, 8, 9, 15] have pointed out that the area is a potentially unstable site, much like the thoracolumbar and lumbar- sacral junction. Lesions at the cervicothoracic junction are easily overlooked, due to poor visualization during the routine radiographic control; other imaging modalities such as swimmer's view, tomograms, CT reconstruction or MRI should be used in doubtful cases [7].

Different instrumentation techniques have been evaluated biomechanically and used clinically for managing instabilities of the middle cervical spine (C3-C6) [13, 19]. Although these studies showed that posterior constructs like plates, wires and cervical rods are superior to anterior plates, there is still limited experience of their use at the cervicothoracic junction. The different anatomic characteristics of the vertebrae at the level of the cervicothoracic junction [1], combined with inherent biomechanical variability [16], impose the need for selection of an adequate surgical technique. This paper reviews our experience in the surgical cases of cervicothoracic junction instabilities and describes clinical findings, instrumentation applied and associated complications.

Materials and methods

This is a retrospective study, reviewing ten surgical patients with spinal problems at the cervicothoracic junction. Cases were collected from 1990 to 1997. There were six male and four female patients. Age ranged from 22 to 75 years. There were six traumatic lesions and four tumours, one of which was complicated with severe post-laminectomy instability. All the patients underwent extensive imaging controls such as plain radiographs, CT reconstruction and MRI. Traumatic cases involved one C7 burst fracture and five C7-T1 dislocations. Tumour cases consisted of three metastatic lesions and one primary malignant lesion. Metastases originated from the lung in one patient, prostate in one, and thyroid in another. The fourth patient with the primary malignant tumour (case 10) had undergone a laminectomy 2 months earlier for decompression of the spinal cord, for what had wrongly been diagnosed as chondroblastoma. The patient had local recurrence of the tumour and the final diagnosis that was established after a one-stage anterior-posterior procedure was chondrosarcoma.

Neurologic function was graded according to the Frankel classification. All patients of the present series presented neurologic deficits (Table 1). Among traumatic cases, there were two incomplete injuries and one complete, whereas three patients had root deficits. The four tumour cases presented significant neurologic involvement. Three patients had incomplete cord syndrome and one patient had root deficits. Decompression of the spinal cord and nerves through a posterior or anterior procedure was performed in all cases (Table 1). Five patients were submitted to posterior procedures only. In two cases the stabilization of the cervicothoracic junction was accomplished with hooks and rods. Two other cases were treated with plates and screws fixed to the lateral masses and pedicles and in one case with wires only. In three cases the cause was fracture dislocation at the cervicothoracic junction, and in the other two tumour lesions.

The other five patients underwent combined anterior and posterior procedures (Table 1). Four of them underwent a one-stage procedure and the fifth a two-stage procedure with a three-week lapse between the two operations due to cardiopulmonary complications (case 9). In three cases the cause was traumatic injury and the rest were due to tumour lesions. A low cervical approach was used on four out of the five patients who were operated anteriorly. In three cases the right side anterior approach was selected and in the fourth case the left one. In the last case the thoracic vertebrae were approached through a standard thoracotomy that entered the chest through the bed of the third rib. This approach was selected for the anterior procedure for vertebrectomy and stabilization in the ninth case, without particular technical problems. For the anterior stabilization of the lower cervical and upper thoracic spine a titanium cylinder was used as well as Morcher and Caspar type plates and screws. Iliac autografts or titanium cylinder filled with methylmethacrylate were used for vertebral body substitution.

Follow-up information was obtained clinically and radiologically and the results were rated as excellent, good, fair or poor. Results were excellent if recovery and return to previous activities occurred; good, if there was only occasional pain, return to painful activities and intermittent use of mild analgesics; fair, if only partial recovery occurred with frequent use of analgesics and modi-

Table 1 Summary of patients

Age/Sex	Diagnosis	Frankel grade (pre-op)/(post-op)	Procedure	Follow-up (months)	Outcome
1. 27/M	C7 neural arch fracture C7-T1 dislocation	Right weakness/ recovery	1. Laminectomies-facetectomies C7 2. Partial C7 corpectomy and discectomy C7-T1, autograft + plating C7-T1 (Morscher plate) 3. Posterior stabilization with iliac autograft and wires (C5-T3)	48	Excellent
2. 31/M	C7 burst fracture	B/C	1. Vertebrectomy-iliac autograft and Caspar plate C6-T1 2. Posterior stabilization with clamps (Sofamor-Danek) C6-T1	6	Fair
3. 60/M	C7 burst fracture C7-T1 sublucation	Bilateral C7 weakness/recovery	1. Laminectomies-facetectomies C7 2. Posterior plating with semitubular AO plates C6-T1 3. Anterior corrective osteotomy C7 autograft and plating with titanium locking screw plate C7-T1	12	Good
4. 22/F	C7 burst fracture C7-T1 subluxation	A/A	1. Partial laminectomies C7-T1 2. Posterior wire fusion (C6-T2)	12	Fair
5. 38/M	C7 burst fracture C7-T1 subluxation	Bilateral C7 weakness/recovery	1. Laminectomies-facetectomies C7 and laminectomies T1 2. Posterior plating (René-Louis plates) C6-T1 and iliac autograft +wire (C5-T2)	18	Excellent
6. 33/F	C7 burst fracture C7-T1 subluxation	C/D	1. Partial laminectomies C7-T1 2. C7-T1 spondylodesis with 2 Roy- Camille plates (C7-T1)	48	Good
7. 56/M	Lung metastasis to T1	C/D	1. Laminectomies C7-T1 2. Posterior spondylodesis with cervical CD + CD (C5-T6)	9 (death)	Good
8. 75/M	Prostate metastasis to T2	C/D	1. Laminectomies C7-T1 2. Posterior spondylodesis with cervical CD + CD (C5-T8)	9	Good
9. 30/F	Thyroid metastasis to T3	C/E	1. Laminectomies (C7-T3 2. Posterior spondylodesis with Hartshill rod-frame 3. Anterior vertebrectomy T3, iliac autograft and DCP plate (T2-T4)	48	Good
10. 41/F	Chondrosarcoma at C7	Right upper extremity weakness/recovery	1. Laminectomies-facetectomies C5-T1 2. Posterior spondylodesis with paediatric TSRH (C3-T3) 3. C7 vertebrectomy, titanium cylinder with methylmethacrylate and plating (C6-T1)	6	Good

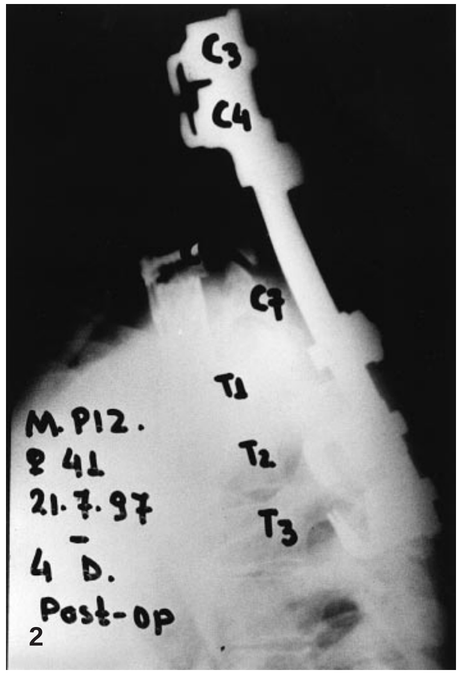

Fig. 1 Post-operative antero-posterior radiograph of a patient. The posterior stabilization has succeeded with paediatric TSRH

Fig. 2 Post-operative lateral radiograph of the same patient. Anteriorly the vertebral body has been replaced by a titanium cylinder filled with methylmethacrylate. The anterior stabilization was completed by an anterior cervical plate

fied activities and poor, if no relief of original symptoms could be noted and pain remained constant with full-time support needed. Post-operatively all the patients had a Minerva type cervicothoracic brace for 3 months.

Results

Follow-up ranged from 6 to 48 months with an average of 22 months. Patients with incomplete cord injury significantly improved their neurologic function by at least one or two Frankel grades (Table 1). One patient improved from grade B to grade C, three others improved from grade C to grade D, and one patient improved from grade C to grade E. All patients with root deficits improved, and at nearly 6 months post-operatively they were restored completely. There was no improvement in neurologic function in the patient with complete cord injury.

There were three excellent, five good and two fair results. In two cases that were treated with spinous processes wiring and one with Hartshill frame-rod with wires no perfect reduction was obtained. Loosening of the wires with subsequent loss of the reduction was noticed a few months later. Fortunately, the loss was not significant and without neurologic deterioration.

Despite the associated problems, we had no complications in the three patients (cases 3, 5, 6) who were stabilized with plates and bicortical screws applied to the lateral masses. Two patients (cases 7, 8) who were treated for metastasis with neurologic deficit, their general medical condition was rather poor. These patients were not able to undergo extensive surgery (anterior-posterior) and their life expectancy was not very long. Therefore, we wanted to obtain alleviation of the pain and neurologic improvement by posterior decompression of the spinal cord and stabilization of the affected area of the spine. In two lesions of traumatic origin (cases 4, 6), the spinal instability and the neurologic deficit were due to destruction of the posterior spinal elements. These injuries were sustained a few days prior to the operation; therefore, it was adequate to remove the destroyed elements through a posterior procedure and to reduce/stabilize the vertebrae with spinous process wiring (case 4) and lateral mass plating (case 6).

Complications included temporary vocal cord paralysis, dysphagia and Horner's syndrome in one case. Other complications included one wound infection, two urinary tract infections, one deep vein thrombosis, one sore ulcer and one pneumonia. All these complications were treated conservatively. One patient died 9 months after the operation due to neoplastic progression. All the patients demonstrated significant relief from pain.

Discussion

Lesions or traumatic injuries at the cervicothoracic junction can be difficult to diagnose. The incidence of injury in this region in spinal cord injured patients can be up to 9% [15]. Evans [8] reported 14 dislocations at the cervicothoracic junction, nearly two-thirds of which were not properly diagnosed on admission. In our series, only one patient, who was admitted elsewhere for head injury due to a road traffic accident, was initially entirely misdiagnosed.

Neurologic sequel due to cervicothoracic lesions is common and found in all cases of the present series. This predisposition to neurologic deficits is probably due to the small canal size of the cervicothoracic junction, but it may also be due to vascular insufficiency [20].

The biomechanics of the cervicothoracic junction are unique due to the transition from a mobile cervical to a rigid thoracic spine [16], and laminectomy tends to cause further instability in this area [21]. The various applied implants have been tested for their ability to successfully stabilize this area. Bueff et al. [5] measured the stiffness of the cervicothoracic junction in vitro, before and after fusion, with three instrumentation systems: the Synthes lateral mass plates (fixed to the vertebrae with screws through the pedicles), the paediatric Cotrel-Dubousset rod system with laminar hooks and a crosslink and the anterior Synthes cervical locking plate. Their data [5] suggested that the Cotrel-Dubousset system provides the largest mean increase in stiffness for all testing modes compared with the unfused spine, and instability of the cervicothoracic junction can be efficiently restored with hook and rod constructs or posterior plates. However, hooks should be avoided in cases of spinal canal stenosis, as they can lead to an iatrogenic spinal cord injury. Systems using hooks and rods have the potential to cover extended levels above and below the cervicothoracic junction, while the clamp system can cover a limited number of vertebral levels, up to three. In our opinion, the combination of instrumentation systems using hooks and rods (Cotrel-Dubousset, paediatric TSRH) provides segmental and rotational stability in all spinal disorders at the cervicothoracic junction. Simultaneously, this combination forms a rigid frame and restores the physiological cervical and thoracic postural contours due to its highly corrective effect in the sagittal plane, providing the possibility for nerve tissue recovery (Figs. 1, 2).

These systems and techniques as well as those that include wires (spinous process and lamina wiring) can be applied whenever there are intact laminae and spinous processes. In cases of lamina or facet injuries, pedicle screw fixation into C7 and T1 is a technically demanding procedure, where the margin of error is small and a good knowledge of the pedicular anatomy of C7 and T1 is required. Anderson et al. [3], in order to avoid the risk of neurologic complications, applied the screws at the lateral mass of the C7-T1 vertebrae. That is not technically demanding, and they reported good clinical results. The system of plates and screws applied posteriorly to the lateral mass of the vertebrae has the advantage of overcoming the problems related to the absence of laminae after laminectomy. In addition the plates and screws can restore the proper alignment of the cervicothoracic area. C7-T1 are transitional vertebrae [1], making lateral mass drilling or probing techniques possible, but also more difficult. If the lateral mass is chosen for C7 fixation, more cephalic and lateral drilling is recommended to gain better bony purchase and to avoid nerve root injury [3]. This technique is limited if the facets are fractured.

The most common posterior approach to the cervicothoracic junction is the midline incision for laminectomy and stabilization with various instrumentation systems. Access to the anterior aspect of the cervicothoracic junction is difficult and potentially dangerous because of bony obstruction such as manubrium, clavicle and ribs and because of nearby vital structures such as great blood vessels, the lung, recurrent laryngeal nerve, thoracic duct, and sympathetic ganglions. The anterior approach to the cervicothoracic junction includes low cervical [10], supra clavicular [10], transthoracic [18], transaxillary [9], a combined cervical and thoracic [14], sternal splitting [9] or modified sternal approaches [4, 12]. Low cervical approach [10] is an extension of the anteromedial approach to the low cervical spine. This approach is limited to the exposure of T1-T2, and can be particularly difficult in patients who have short necks with high shoulders. This approach is recommended for simple discectomy and interbody fusion at C7-T1 or for biopsy [2].

Upper thoracic vertebrae may also be approached through a standard thoracotomy that enters the chest through the bed of the third rib. However, the scapula and remaining ribs restrict access to the low cervical region [11].

Conclusions

The individual anatomic characteristics of the cervicothoracic junction as well as the post-traumatic alterations that occur, demand a very careful pre-operative study of the anatomy of the area and pre-operative planning of the surgical procedure [5]. Patients who have undergone traumatic disruptions or laminectomies should receive stabilization and fusion. In cases of extensive destruction of the posterior elements, extensive laminectomies-facetectomies are recommended, and whenever vertebrectomy is obligatory, due to destruction of the vertebrae, a combined posterior and anterior approach is recommended. In cases of a long-standing lesion, we usually proceeded posteriorly first, for removal of the destroyed and interposed spinal elements, and spondylodesis followed. The anterior procedure is used for anterior decompression by vertebrectomy and stabilization. In the one-stage posterior and anterior approach it is necessary for the patient to be in good physical condition. The posterior approach is recommended in patients where partial laminectomy is performed and preservation of the facets is maintained, and whenever the anterior elements are intact. The length of the posterior spondylodesis has significant importance, especially in cases with poor general condition or in extensive multi-level laminectomies-facetectomies. In these cases the extensive posterior spondylodesis reduces the necessity for a complementary anterior spondylodesis and the risk of late loss of correction and stabilization. Complications of surgery at the cervicothoracic junction are not uncommon: therefore, good surgical techniques and post-operative immobilization are important.

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