Late radiographic findings after the anterior cervical fusion for the cervical subaxial compressive flexion and vertical compression injuries in young patients

Bronius Špakauskas, Kazys Vytautas Ambrozaitis, Arimantas Tamašauskas, Egidijus Kontautas[1]
Department of Neurosurgery, [1]Department of Orthopedics and Traumatology, Kaunas University of Medicine, Lithuania

Key words: *cervical spine; cervical spine injury; spine stabilization.*

Summary. *Objective. The aim of this study was to investigate the influence of patients' age on the development of radiologic signs of degeneration of adjacent levels after the anterior fusion for the cervical spine injuries.*

Material and methods. A total of 45 patients who had compressive flexion and vertical compression injuries of the cervical spine (by Ferguson–Allen mechanistic classification) were included in the study. There were 40 male and 5 female patients with a mean age of 31.5 years (range 15–64). These patients were treated with anterior decompression, iliac bone grafting, and anterior plating. Twenty-two patients aged less than 30 years were in the first group; 23 individuals more than 30 years of age were in the second group. A long-term radiologic follow-up involved assessment of the fusion and examination of the changes at levels immediately above and below the fused vertebrae.

Results. Hypermobility of the disc space above the fused vertebra was found in 9 (40.9%) patients from the first group vs. 3 (13%) from the second one ($P<0.05$). Narrowing and osteophytes of the disc space below the fused vertebra was found in 2 (9.1%) patients from the first group vs. 10 (43.5%) from the second one ($P<0.05$).

Conclusions. Hypermobility of the motion segment above the fused vertebra was found more frequently in patients aged less than 30 years. Narrowing and osteophytes of the disc space below the fused vertebra were found more frequently in older patients.

Introduction

Traumatic conditions including compressive flexion and vertical compression injuries of the cervical spine are often treated surgically with corpectomy, anterior strut grafting, and anterior cervical plating (1–3). Clinical studies show that corpectomy, anterior strut grafting, and anterior cervical plating for unstable lower cervical spine fractures is a safe technique with a union rate approaching 100%, without residual kyphosis, and with minimal symptomatic neck pain (2, 4, 5). However, the anterior fusion of spinal segments leads to an excessive stress at unfused adjacent levels and can accelerate its degeneration (2, 6). In this study, an evaluation of the late radiographic changes that occur after the anterior fusion was performed, with a particular emphasis on the nonfused neighboring spinal levels, and the influence of the patient's age on the development of these changes was investigated.

Material and methods

Patient population

In 5 years between 1998 and 2003, 58 patients who had compressive flexion and vertical compression injuries of the cervical spine (by Ferguson–Allen mechanistic classification) were managed with the anterior decompression and arthrodesis at the Kaunas University of Medicine Hospital (7). Of the original 58 patients, 13 were excluded from the study: 5 were lost to follow-up and 8 died of causes unrelated to the operation (pneumonia, pulmonary thromboembolism, cardiovascular disease) and were not adequately followed up. Thus, 45 patients were included in the study. These patients were followed up for an average of 3.1 years (range 1–6 years). Patients were divided into two groups according to the patients' age at the trauma and surgery. Patients aged less than 30 years were in the first group, and the individuals aged more than 30 years were in the second group. There were 40 (88.9%)

Correspondence to B. Špakauskas, Department of Neurosurgery, Kaunas University of Medicine, Eivenių 2, 50009 Kaunas, Lithuania. E-mail: spak@takas.lt

male and 5 (11.1%) female patients with a mean age of 31.5 years (range 15–64).

Patient management

On admission to hospital after assessment of the initial status of the patient and neurologic examination (guidelines established by the American Spinal Injury Association were used), the pattern of the cervical spine injury was established by a radiographic evaluation and computed tomography scanning (8).

Surgical technique

The surgical procedure was performed within 48 hours after admission to hospital. The patients were placed supine with a small roll placed horizontally beneath the shoulders. The neck flexion and extension were assessed preoperatively to ascertain optimum patient positioning. Fluoroscopy was used in every case. Antibiotic drugs (typically a first-generation cephalosporin) were administered intravenously on the patient's arrival at the operating room. The standard endotracheal intubation was performed via direct laryngoscopy. A standard anterior approach to the cervical spine was used. Exposure was limited to one vertebral body above and below the vertebral body to be excised. The tricortical bone graft harvested from the iliac crest was inserted into intervertebral space, and the stabilization using the plate and screws was performed. After the plate was positioned, an intraoperative cross-table fluoroscopy was performed to confirm placement of the graft and instrumentation. The wound was closed in the layers over a closed suction system.

Postoperative management

Postoperatively, all patients wore a rigid cervical collar during the first 8 weeks. All the patients received comprehensive rehabilitation program. Clinical and radiographic evaluations (including standard and flexion-extension radiography) were conducted in 1 week and 8 weeks after the surgery.

Follow-up studies

Follow-up studies consisted of a repeated neurological examination as well as flexion/extension radiographs. Lateral cervical spine films were taken with the patient sitting with the neck in the flexion or extension position (patients were asked to flex and extend their spine as much as possible during each examination). The patient's shoulder was in contact with the film tray, and the distance from the radiation source to the film tray was set to 150 cm. The early x-ray examination performed in the immediate postoperative period was made in the same fashion. A long-term radiologic follow-up involved assessment of the fusion and examination of the changes at the levels immediately above and below the fused vertebrae. Cervical radiographs were reviewed by an independent radiologist.

The fusion was considered complete when a trabecular bone across the interface between vertebral plates and bone graft appeared and when margins between a bone graft and vertebral bodies disappeared. The fracture of implant and screw displacement were determined visually by inspecting the displacement of screw heads beyond the most anterior aspect of the plate, a gap between the plate and underlying vertebral body, lucency around the screws, a broken screw as indicated by a radiological lucency, a gap through the screw or an angle along the course of the screw. The degree of disc narrowing and anterior osteophytosis at the superior and the inferior adjacent levels were assessed by a comparison with early radiographs, obtained in the immediate postoperative period.

The horizontal displacement of one vertebra in relation to an adjacent vertebra either anteriorly or posteriorly was measured. It was measured by the following technique: a point at the posteroinferior angle of the vertebral body above the interspace in the question was marked and a point at the posterosuperior angle of the vertebral body was also marked; the distance between the two in the sagittal plane was measured. When more than a 2.5-mm vertebral slip was noted anteriorly or posteriorly, it was considered abnormal and was defined as hypermobility of the motion segment (9).

Statistical analysis

Statistical comparisons between various subsets of patients were performed with the use of chi-square (χ^2), Fisher (F) exact test, and t test for independent samples. A value of $P<0.05$ was considered to indicate that the difference was significant.

Results

The two groups were comparable for baseline, demographic data and for an American Spinal Injury Association (ASIA) motor score (8).

Diving accident was the most common mechanism responsible for compressive flexion vertical compression injuries (27 of the 45, 60%).

At late follow-up, additional radiologic degeneration at the adjacent disc levels was found in 14 (63.6%) patients from the first group and in 15 (68.2%) from the second group $P(\chi^2)>0.05$.

Table 1. **Baseline variables**

Characteristic	The first group N=22	The second group N=23	Probability value
Male	19 (86.4%)	21 (91.3%)	P(F)>0.05
Female	3 (13.6%)	2 (8.7%)	P(F)>0.05
Age, mean±SD, years	22.1±4.4	39±8.8	P(t)<0.05
Level of injury			
C3	0	2 (8.7%)	P(F)>0.05
C4	2 (9.1%)	1 (4.3%)	P(F)>0.05
C5	10 (45.5%)	5 (21.7%)	P(χ^2)>0.05
C6	5 (22.7%)	6 (26.1%)	P(χ^2)>0.05
C7	5 (22.7%)	9 (39.1%)	P(χ^2)>0.05
Pattern of injury			
Compressive flexion	15 (68.2%)	11 (47.8%)	P(χ^2)>0.05
Vertical compression	7 (31.8%)	12 (52.2%)	P(χ^2)>0.05
Grade of spinal cord injury			
ASIA-A	8 (36.4%)	7 (30.4%)	P(χ^2)>0.05
ASIA-B	3 (13.6%)	4 (17.4%)	P(F)>0.05
ASIA-C	0	2 (8.7%)	P(F)>0.05
ASIA-D	5 (22.7%)	6 (26.1%)	P(χ^2)>0.05
ASIA-E	6 (27.3%)	4 (17.4%)	P(F)>0.05

Table 2. **Radiographic signs of degeneration of disc spaces above to the site of cervical arthrodesis**

Sign	The first group N=22	The second group N=23	Probability value
None	9 (40.9%)	10 (43.5%)	P(F)>0.05
Narrowing and osteophytes	4 (18.2%)	10 (43.5%)	P(F)>0.05
Hypermobility	9 (40.9%)	3 (13%)	P(F)<0.05

Table 3. **Radiographic signs of degeneration of disc spaces below to the site of cervical arthrodesis**

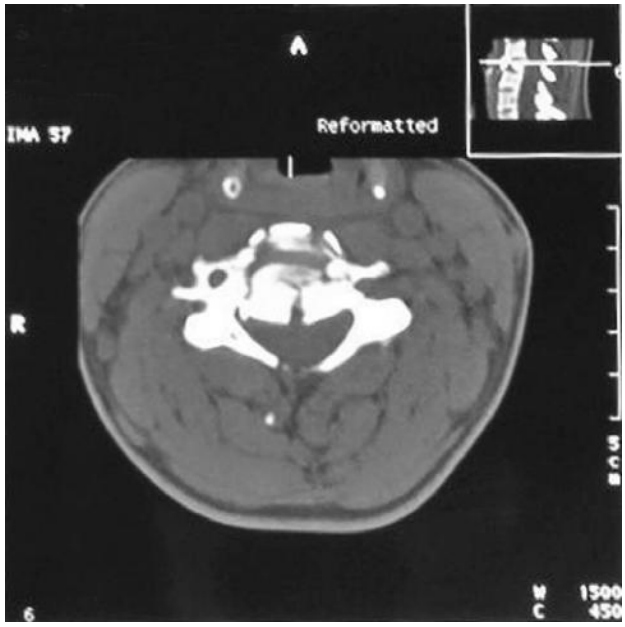
Sign	The first group N=22	The second group N=23	Probability value
None	19 (86.4%)	13 (56.5%)	P(F)<0.05
Narrowing and osteophytes	2 (9.1%)	10 (43.5%)	P(F)<0.05
Hypermobility	1 (4.5%)	–	P(F)>0.05

The cervical radiographic examination performed during the follow-up period demonstrated 3 (6.7%) cases of a partial screw pullout. The fusion was successful in all cases (100%).

Discussion

The anterior cervical decompression and fusion procedures have become widely used in the treatment of various axial spine pathological entities. The general indications are the need for the spinal stabilization to avoid a neural injury and axial spine deformity (10). Despite this, the anterior fusion of spinal segments leads to an excessive stress at the unfused adjacent levels and can accelerate its degeneration (2, 6, 11). From the biomechanical point of view, an altered physiologic load by the elimination of motion at one spinal

A



B

C

D

Fig. **Radiographs of a 20-year-old patient**

The patient sustained a C5 compressive flexion fracture (A–B) in a car accident and underwent an anterior decompression and plate fixation. Lateral flexion/extension (C–D) radiographs 1 year following surgical procedure show hypermobility at the adjacent disc levels.

segment will produce an increased stress and hypermobility at the adjacent segments. A few biomechanical studies of the cervical spine have investigated the altered biomechanics at the adjacent segments after arthrodesis and have demonstrated increased intradiscal pressure stress within vertebrae and changes in motion (11–13). At the late follow-up after the cervical interbody fusion and in comparison with the initial radiographic findings, additional degeneration at the superior and/or inferior adjacent disc levels was found in 64.4% of our cases which also compares favorably with the range of 50.4% to 92% in the literature (2, 14). In our current study, we found radiologic signs of degeneration at the adjacent levels in 63.6% of the 22 cases from the first group and in 68.2% of the 23 patients from the second group. The similarity of progression to degeneration at the adjacent levels among the patients of these two groups suggests that not only natural progression of pre-existing degenerative disc disease but also biomechanical factors due to the interbody fusion itself are important. We found that the flexion-extension rotational movement of the disc in the sagittal plane increased after an anterior fusion at the upper adjacent level in younger patients from the first group too. This compares well with data reported in the literature (9).

In this study, the instrumentation failure rate (defined as radiological evidence of screw pullout) was 6.7%, which also compares favorably with the range of 5% to 17% in the literature (10, 15, 16). We found fusion rate of 100%. This compares well with rates reported in the literature that range from 72% to 100% (4, 10, 17).

Conclusion

Hypermobility of the motion segment above the fused vertebra was found more frequently in patients less than 30 years of age. Narrowing and osteophytes of the disc space below the fused vertebra was found more frequently in the older patients.

Jaunų pacientų stuburo kaklinės dalies rentgenologiniai pokyčiai, išsivystę po priekinės rekonstrukcijos dėl spaudimo lenkimo ir ašinio spaudimo sužalojimų

Bronius Špakauskas, Kazys Vytautas Ambrozaitis, Arimantas Tamašauskas, Egidijus Kontautas[1]
Kauno medicinos universiteto Neurochirurgijos klinika, [1]Ortopedijos ir traumatologijos klinika

Raktažodžiai: stuburo kaklinė dalis, stuburo kaklinės dalies sužalojimas, stuburo fiksavimas.

Santrauka. *Darbo tikslas.* Ištirti paciento, patyrusio traumą, amžiaus įtaką stuburo kaklinės dalies rentgenologinių pokyčių išsivystymui po priekinės rekonstrukcijos.

Tyrimo medžiaga ir metodai. Ištirti 45 pacientai, patyrę spaudimo lenkimo ir ašinio spaudimo (remiantis Ferguson–Allen mechanistine klasifikacija) stuburo kaklinės dalies sužalojimus. Tyrime dalyvavo 40 vyrų ir 5 moterys, kurių amžiaus vidurkis – 31,5 metų (nuo 15 iki 64 metų). Visiems pacientams pašalintas lūžęs slankstelio kūnas bei šalia jo esantys tarpslanksteliniai diskai, taip pat atlikta priekinė stuburo kaklinės dalies rekonstrukcija ir fiksacija. 22 pacientai iki 30 metų buvo pirmoje, o 23 vyresni kaip 30 metų – antroje grupėje. Vėlesniu pooperaciniu laikotarpiu tirti tarpslankstelinių diskų, esančių aukščiau ir žemiau fiksuotų slankstelių, pokyčiai.

Rezultatai. Padidėjęs judrumas tarpslankstelinio disko, esančio aukščiau fiksuoto slankstelio, nustatytas 9 (40,9 proc.) pirmos ir 3 (13 proc.) antros grupės pacientams ($p<0,05$). Tarpslankstelinio disko, esančio žemiau fiksuoto slankstelio, aukščio sumažėjimas ir slankstelių dengiamųjų plokštelių kaulinių išaugų susiformavimas nustatytas 2 (9,1 proc.) pirmos ir 10 (43,5 proc.) antros grupės pacientų ($p<0,05$).

Išvados. Pacientams iki 30 metų amžiaus dažniau išsivystė padidėjęs judrumas tarpslankstelinio disko, esančio aukščiau stuburo kaklinės dalies artrodezės. Vyresniems ligoniams dažniau nustatytas sumažėjęs tarpslankstelinio disko, esančio žemiau spondilodezės, aukštis bei susiformavusios slankstelių dengiamųjų plokštelių kaulinės išaugos.

Adresas susirašinėti: B. Špakauskas, KMU Neurochirurgijos klinika, Eivenių 2, 50009 Kaunas
El. paštas: spak@takas.lt

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