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Risk Factors for Adjacent Segment Disease Development after Cervical Fusion

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Abstract

Introduction: Adjacent level degeneration following anterior cervical discectomy and fusion (ACDF) has been well documented in recent literature, yet there remains considerable controversy as to when adjacent level radiographic degeneration becomes clinically relevant. Several risk factors have been suggested to be involved in the occurrence and progression of adjacent segment degeneration and disease (ASD). This study tries to address these risk factors and the possible measures to minimize their effects.

Material and Methods: This study included 38 patients who have had single or double level ACDF at least 2 years earlier, who have been symptom free for at least 6 months after surgery and who have suffered persistent neck and/or radicular symptoms for at least 6 weeks. Indications for ACDF in those patients were the treatment of Cervical degenerative disc disease (CDDD) with radiculopathy, myelopathy or both. Fusions in the index surgical levels were assessed on the X-rays as bridging bone across the disc space between the adjacent end-plates. Any pseudoarthrosis or implant loosening was noted on dynamic films. The motion segments caudal and cranial to the fused segments were radiologically examined and were said to show adjacent segment degeneration if they showed: disc space narrowing, end-plate sclerosis or osteophytes, anterior or posterior translation of 2mm or more, or more than 10 degrees difference in disc space angulation in flexion and extension. MRI evidence of ASD included: decreased disc height, low signal intensity on sagittal T2 images, disc protrusion or prolapsed or foraminal narrowing with nerve root entrapment on Axial T2 images. Patients where then divided in groups according to the risk factors, Number of fused segments Method of fusion, Time since index surgery, Sagittal attitude of cervical spine, Age, gender

Results: Most common fusion level was C5-C6 (62%of all fused levels), followed by C4-C5 (31%). Most common ASD were C6-C7 motion segments. The highest incidences of ASD were found among patients with loss of normal cervical lordosis (79%) and patients with time intervals from fusion being more than 5 years (62%). The difference of ASD incidences between patients with single and double fused levels, methods of fusion used and demographic characteristic was not statistically significant.

Conclusion: The development of adjacent level degeneration following cervical fusions is related to several preoperative and postoperative mechanical factors. Yet, the aging process of spine may be involved. Proper sagittal alignment plays a strong role in avoiding and delaying ASD. Literature seems to support a multivariate etiology of this phenomenon rather than being secondary to compensation of the lost motion in fused segments. Consideration of patient risk factors as well as fusion technique may help delay progression to clinical ASD and consequently need for further surgeries. Pre-existing disc pathology and post-operative sagittal malalignment rather than the number of fused segments appears to have a strong influence on the development of ASD.

Keywords: *Adjacent segment disease; Fusion; Sagittal balance*

Introduction

Cervical degenerative disc disease (CDDD) is a common disease that can present with variable severity as well as variable response to conservative treatment. It commonly results in radiculopathy, myelopathy or both. When conservative treatment fails, anterior cervical discectomy and fusion (ACDF) can be offered to patients. ACDF has been used widely for treating such disease with high success rates. This led to a rapid increase in rates of ACDF

performance in the past 3 decades. One draw-back of ACDF is the acceleration of degenerative changes in the nearby motion segments [1-3].

Adjacent level degeneration following ACDF has been well documented in recent literature, yet there remains considerable controversy as to when adjacent level radiographic degeneration becomes clinically relevant [3].

It is important, therefore, to understand the long-term consequences of cervical fusions, and their impact on adjacent segment degeneration. Several risk factors have been suggested to be involved in the occurrence and progression of adjacent segment degeneration and disease (ASD). This study tries to address these risk factors and the possible measures to minimize their effects.

Patients and Methods

This study included 38 patients who have had single or double level ACDF at least 2 years earlier, who have been symptom free for at least 6 months after surgery and who have suffered persistent neck and/or radicular symptoms for at least 6 weeks. Indications for ACDF in those patients were the treatment of CDDD with radiculopathy, myelopathy or both.

Patients presented to the spine outpatient clinic complaining of neck pain and stiffness with shoulder or radicular pain. Plain X-rays (static and dynamic) and MRI were performed for all patients. Medical and physical therapy were initially prescribed for all patients. Medications included NSAIDs, neuropathic pain killers, neurotonics, muscle relaxants and intramuscular injection of steroids. Patients who presented with neurological deficits (motor, sensory or reflexes) or those who did not respond to conservative treatment within 6 weeks were offered the surgical re-intervention.

Fusions in the index surgical levels were assessed on the X-rays as bridging bone across the disc space between the adjacent end-plates. Any pseudoarthrosis or implant loosening was noted on dynamic films. The motion segments caudal and cranial to the fused segments were radiologically examined and were said to show adjacent segment degeneration if they showed: disc space narrowing, end-plate sclerosis or osteophytes, anterior or posterior translation of 2mm or more, or more than 10 degrees difference in disc space angulation in flexion and extension. MRI evidence of adjacent segment degeneration included: decreased disc height, low signal intensity on sagittal T2 images, disc protrusion or prolapsed or foraminal narrowing with nerve root entrapment on Axial T2 images.

The changes on X-rays and MRI were compared to those on older imaging. Patients showing moderate to marked changes were analysed for the type of risk factor (Table 1).

Risk factors	Subgroups
Number of fused segments	Single level
	Double level
Method of fusion	Plate and autograft
	Plate, cage and autograft
	Cage and autograft
Time since index surgery	2-5 years
	More than 5 years
Sagittal attitude of cervical spine	Lordotic
	Hypolordotic
	Straightened or kyphotic
Age	Older (>40yrs)
	Younger (<40yrs)
Gender	Males
	Females

Table 1: Patients where then divided in groups according to the above-mentioned risk factors

All patients were considered as having adjacent segment disease and not just degeneration as all of them were presenting with persistent cervical spine complaints.

Results

The 38 patients were 22 males and 16 females aged 29 to52 (mean =39) years. Twelve patients (31.6%) had predominant axial neck pain with shoulder pain but minimal or no radicular upper limb pain, 20 patients (52.6%) had neck and

shoulder pain without arm pain, and 5 patients (13.2%) had predominantly radicular arm pain with minimal neck pain. The mean time interval since the index surgery was 3.6 (range, 2-7) years.

Most common fusion level was C5-C6 (62%of all fused levels), followed by C4-C5 (31%). Most common ASD were C6-C7 motion segments. The highest incidences of ASD were found among patients with loss of normal cervical lordosis (79%) and patients with time intervals from fusion being more than 5 years (62%) (Figure 1, 2).

Figure 1: Showing ASD in the form of disc degeneration and bulging proximal to a single level fusion in a patient 65 years old who shows partial loss of cervical lordosis

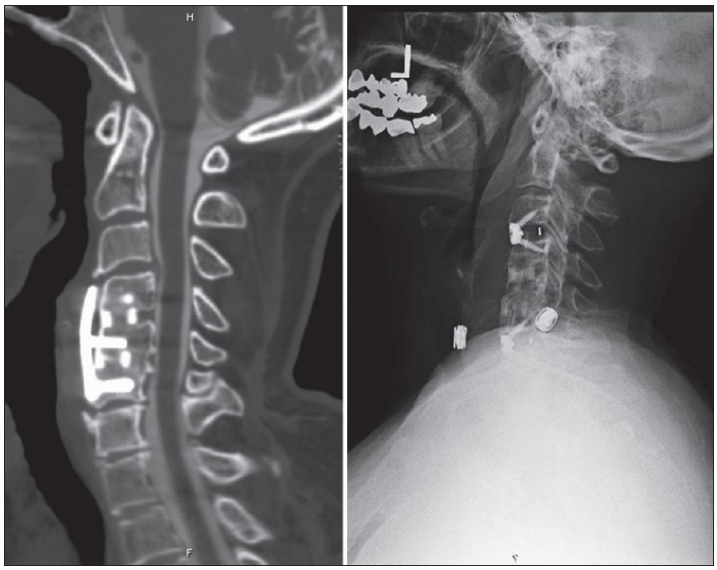

Figure 2: Showing proximal and distal disc degeneration and prolapsed following double level fusion of C4-C5 and C5-C6. Note the hypo-lordotic attitude of the cervical spine

The difference of ASD incidences between patients with single and double fused levels, methods of fusion used and demographic characteristic was not statistically significant (Table 2).

Risk factors	Adjacent segment disease incidence	P value
Single vs double level fusion	20% vs 24%	P>0.05
Plate alone vs plate-cage vs cage	26% vs 22% vs 21%	P>0.05
Older (>40yrs) vs younger (<40yrs) age	29% vs 22%	P>0.05
Males vs females	27% vs 21%	P>0.05

Table 2: Showing incidences of adjacent segment disease among patients with different risk factors

Discussion

The pathophysiology of intervertebral disc degeneration cascade has been studied by many investigators. Numerous factors have been suggested as influencing its etiolog, including mechanical factors, such as compressive loading,

shear stress, vibration, as well as ageing, genetic, systemic and toxic factors, which can lead to degeneration of the disc through a cascade of biochemical reactions [4].

Degenerative disc disease eventually reduces the mobility of the cervical motion segments and creates local kyphosis that must be compensated by the other levels, thereby accelerating their own process of degeneration. This may be a factor that starts adjacent segment degeneration before spinal fusion is even offered to patients [3,4].

ACDF is regarded as the gold standard procedure for the treatment of single or multilevel cervical spondylosis leading to radiculopathy and/or myelopathy. It has been proven to be a safe and reliable technique. Since spinal fusion is being performed on younger patients and as the rates of cervical spine surgery have markedly increased over the past 25 years, concern regarding the effect on adjacent motion segments has been increasing. And while indications for fusion have expanded to include mechanical neck pain with more variable success rates, concern for adjacent segment degeneration has been amplified [5-8].

Goals of cervical fusion include removal of the disk as a generator of pain, and more essentially appropriate decompression of the neurological elements and restoration of disc height that will indirectly restore the caliber of the neural foramen. It has also become evident that maintenance of sagittal alignment of the spine has its important clinical effect when aiming at the avoidance of adjacent segment degeneration [5]. In our study, highest incidence of ASD was observed in patients with loss of normal cervical lordosis irrespective of the number of motion segments fused and patient's age.

Numerous studies have demonstrated that in properly selected patients, decompression and fusion can yield marked improvement with respect to pain and outlook for various conditions of the spine. However, there are also numerous articles that suggest otherwise, with the results of spinal fusion described as unpredictable, if not unsatisfactory, and often precipitating further surgical intervention [6,9-11].

Fusion of a motion segment results in compensatory increase in motion and subsequently increased loads to adjacent levels, which may accelerate degeneration. Incidences of adjacent segment disease after cervical fusion were reported by Hilibrand., *et al*. in 1999 to occur in 2.9%/ year with 66% re-operation rate [12]. Katsuura., *et al*. in 2001 also reported a 50% incidence of adjacent disc degeneration after 9.8 years with resultant kyphosis of fused segments occurring in 77% of cases [13]. Goffin., *et al*. in 2004 stated that there was a 36% clinical deterioration after 8 years in patient with cervical fusion for degenerative disc disease with 6% re-operation rate [12-14].

Hilibrand (in 2004) and Robbins (in 2005) reported that, annually, 2.9% of patients developed adjacent segment disease after ACDF that required cervical intervention [17,18]. Baba., *et al*. reviewed the cases of 106 patients with cervical spondylotic myelo-radiculopathy who were treated with ACDF and reported that spinal stenosis had occurred at adjacent segments in 25% of the patients during an 8.5 year follow up period.

In cases of multilevel cervical DDD, ACDF still remains the most largely accepted procedure with a satisfactory clinical outcome and proven radiological fusion ranging from 90 to 100%. However, longer fusions may cause greater stresses at adjacent levels than single level fusion and are more likely lead to ASD [13,14].

This fact has been investigated thoroughly and its presence has been proved by an increase in the intradiscal pressure in biomechanical testing studies. This is expected to result in living subjects in more mobility and later on, instability as manifested by stress films studies. More than 3 mm movement of the proximal vertebra over the caudal one in lateral X-ray dynamic films, osteophyte formation and lateral translation are considered signs of radiographic adjacent segment degeneration.

Schwab., et al. examined the cervical spine kinematics in a human cadaveric study and found that a greater compensation occurred at the inferior adjacent segments for the lower levels (C5-C6, C6-C7) fusion, while the superior adjacent segments had greater compensation than the inferior segments when the upper levels (C3-C4, C4-C5) were fused [15]. Bearing in mind that the commonest level for cervical fusion are C5-C6 (for a single level fusion), it would be expected that adjacent segment degeneration are more common at the inferior adjacent segments [16-18]. This was similar to the results obtained by Lee., *et al*. [19]. This agrees with our results in having common ASD of C6-C7.

Elimination of painful disc disease with restoration of sagittal alignment seems to play an important role in averting adjacent level degeneration, as well as being vital to a successful surgical outcome [20]. This can be explained by the fact that multi-level cervical fusions could possibly have similar rates of ASD as single level fusions when adjacent degenerated discs are included in the fusion.

In the previously cited study by Hilibrand and associates that evaluated adjacent level degeneration following cervical spinal fusion, it was demonstrated that the risk of new disease at an adjacent level was significantly lower following a multilevel arthrodesis than it was following a single-level arthrodesis [1]. The study concluded that all degenerated segments causing radiculopathy or myelopathy should be included in an anterior cervical arthrodesis. It was their belief that further degeneration is likely secondary to progression of the disease process rather than the result of the fusion itself [1].

This should make us avoid single level ACDF when treating CDDD of C5-C6 while having a moderately degenerated C6-C7 motion segment. It is better thus to perform 2 level ACDF (C5-C7) especially when X-rays show disc space narrowing and osteophyte formation even without related radicular C7 distribution affection.

Herkowitz and coworkers studied 44 patients with cervical radiculopathy randomized to anterior discectomy and fusion versus posterior foraminotomy with 4.5 years follow-up. Forty-one percent of those undergoing anterior fusion developed adjacent level radiographic degeneration [20]. Interestingly, 50% of those undergoing foraminotomy without fusion developed radiographic adjacent segment changes as well. As in the previously cited studies, no correlation was reported between radiographic degeneration and clinical symptoms [20].

We did not find a correlation between age or gender and a higher incidence of ASD. This is contrary to other studies which found that age is an influential risk factor in developing ASD. This can be explained by the smaller number of patients as well as the relatively younger age population included in our study (below 60 yrs. of age).

Conclusion

The development of adjacent level degeneration following cervical fusions is related to several preoperative and postoperative mechanical factors. Yet, the aging process of spine may be involved. Proper sagittal alignment plays a strong role in avoiding and delaying ASD. Literature seems to support a multivariate etiology of this phenomenon rather than being secondary to compensation of the lost motion in fused segments. In order to obtain best clinical outcomes for the longest time interval, surgeons must consider risk factors present in each patients independently.

Till the present time, clinical symptoms and signs are not always correlated to radiographic findings of adjacent segment disease. The incidence of clinically relevant ASD is much lower than the reported incidence of radiographic ASD. Only 50% with radiographic ASD become clinically symptomatic.

Consideration of patient risk factors as well as fusion technique may help delay progression to clinical ADS and consequently need for further surgeries. Pre-existing disc pathology and post-operative sagittal mal-alignment rather than the number of fused segments appears to have a strong influence on the development of adjacent segment disease.

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