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The use of plate fixation in anterior surgery of the degenerative cervical spine: a comparative prospective clinical study

Received: 12 November 1999
Revised: 26 July 2000
Accepted: 9 August 2000
Published online: 20 June 2001
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Abstract The method of anterior mono- or bisegmental cervical spine fusion is a well-established procedure for degenerative conditions of the cervical spine. While the early reports promote fusion with bone graft alone, recent studies report superior results with the addition of anterior plating. The objective of this study was to evaluate the influence of using plates in anterior cervical spine fusion in a prospective study. Fifty candidates for anterior mono- or bisegmental cervical spine fusion were randomly and prospectively selected and assigned to a plated and a non-plated group. After a minimum follow-up of 22 months, patients were clinically and radiologically examined. The reduction in pain, improvement in neurology and functional assessment showed a significant improvement in both groups

compared to the preoperative values. The total neurological score improved significantly in both groups, but the changes were greater in the group with plates. There was no significant difference between the groups for fusion rating, but graft quality (graft height) was significantly better in the plated group. We conclude that the overall data do not suggest better results with plating in mono- or bisegmental anterior spine fusions. Indications for additional internal fixation are restricted to special conditions with increased instability, insufficient bone quality or inappropriate graft placing.

Key words Anterior cervical spine fusion · Prospective study · Autologous bone graft · Internal fixation

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Introduction

The anterior approach for surgery to solve problems of degenerative conditions in the cervical spine belongs to the “classics” of spine surgery, and is a generally approved procedure [1, 3, 4]. In the majority of the cases, the pathology is restricted to one or two segments. Minor deformations and localized compressive syndromes may be managed by a transdiscal procedure followed by anterior interbody fusion using bone graft. With appropriate decompression and by restoring the original height of the foramen, this surgical procedure is able to decompress nerve root entrapment and resolve radicular pain [1, 2]. In

selected cases, axial neck pain also represents an indication for anterior fusion procedure [15]. Postoperative stability and restoration of the anterior column is provided by the intervertebral bone graft, which is prevented from dislocation either by the tension of the intact soft tissue increasing friction or by application of an anterior plate. The indication for anterior plates, however, is still controversial. Although the original method provided satisfactory results without plates [4], the recent development of various designs of anterior cervical spine plates increased the indication for this type of internal fixation.

We conducted a prospective semi-randomized study to evaluate the value of anterior plates for mono- or bisegmental fusion of the degenerative cervical spine.

Fig. 1 Follow-up of a 45-year old patient with C5–C7 anterior interbody fusion with plate fixation. There is solid fusion with incorporation of the bone-graft

Materials and methods

Patients

Fifty-four patients underwent mono- or bisegmental anterior cervical spine fusion for degenerative conditions, performed by a single surgeon. The patients were randomly assigned to two comparable groups. Fifty patients were available for clinical and radiological follow-up examination by an independent examiner. Three patients could not be found due to migration, one patient was not willing to visit the hospital for the follow-up, but gave assurances that he was satisfied with the results of the surgery. The enrollment to the groups was “randomized” according to the chronological admission to the hospital. In the group with plate fixation (Fig. 1), there were 24 patients (12 men, 12 women) and in the group without plates, 26 patients (11 men, 15 women). The average age of the patients in the plate group was 54 (range 25–73) years, and in the no-plate group 49 (range 24–74) years ($P=0.32$). In the plate group, 54% of fusions were monosegmental and 46% bisegmental; in the non-plate group, 62% were monosegmental and 38% bisegmental ($P=0.50$). The two groups were statistically comparable regarding gender and age ($P>0.05$). Differences between the groups were analysed using *t*-tests and analysis of variance (for continuous data that were normally distributed) and Chi-square and Mann-Whitney U tests (for categorical and ordinal data respectively).

Both groups underwent the identical surgical procedure of anterior mono- or bisegmental fusion, according to the underlying pathology, performed by a single surgeon. The indication in all patients was painful degenerative changes with compressive osteophyte formation and/or disc protrusions. Indication was set by clinical symptoms, conventional radiographs and magnetic resonance (MR) images. Decompression was performed according to the underlying pathology, with disc removal in all patients and posterior osteophyte removal in 31 patients (17 in the non-plate, 14 in the plate group). All patients underwent anterior fusion with autologous iliac crest bone graft (Fig. 2). The treatment of both groups differed in the application of plate only.

Preoperative assessment

The average preoperative pain on a visual analogue pain scale (0–10) was 8.7 for the plate group and 8.4 for the non-plate group.

Ninety-two percent of the plate group (22 patients) and all the 26 patients in the non-plate group were preoperatively under regular drug administration.

Disturbances of sensibility (hypoesthesia or dysaesthesia) in the upper extremities was noted in 38 patients (21 in the plate group, 17 in the non-plate group). Muscular weakness was reported in nine patients in the plate group and in seven patients in the non-plate group. In 13 patients in the plate group there was an asymmetry of reflexes, whereas six patients in the non-plate group had asymmetry of reflexes.

The functional examination concentrated on motion of the cervical spine. Flexion/extension was measured with the chin-sternum distance (for flexion, severely restricted: chin-sternum distance >3 cm, for extension: chin-sternum distance <15 cm), and axial rotation in extension, flexion and neutral position was assessed, categorised as no restriction ($>45^\circ$ from neutral), moderate restriction (20 – 45° from neutral) and severe restriction (0 – 20° from neutral). In the plate group flexion was severely restricted in 14 patients and extension in 17 patients, while in the non-plate group flexion was severely restricted in 13 patients and extension in 13 patients. Twenty-one patients had severe restriction in all three positions for rotation in both groups.

Operative technique

The patient is positioned supine with extended cervical spine. A right-sided transverse antero-lateral incision of about 5–7 cm is performed, except for the segment below C7, where a left-sided approach is preferred in order to avoid damage to the recurrent nerve. After dissecting the platysma and the fascia colli, the anterior longitudinal ligament is exposed by blunt dissection. A lateral radiographic verification of the correct segment is performed and the disc is excised. Decompressive procedures such as osteophyte removal or resection of the uncinate process are added at this stage of the procedure if needed. Decortication of the endplate with sharp osteotomes precedes the insertion of a cortico-cancellous bone graft. A thin layer of the endplate is removed until bleeding from the subchondral bone is observed, in order to preserve stability and prevent countersinking of the bone graft. The wedge-shaped, bicortical bone graft, harvested with an oscillating saw from the iliac crest, is slightly oversized (2–3 mm). It is placed under segmental distraction with the cortical side ventrally, using two

Fig. 2 Two-year follow-up in a 57-year-old woman with C4/5 and C5/6 fusion without a plate. Solid fusion and graft incorporation with bridging trabeculae are apparent

Fig. 3 Monosegmental C5/6 interbody fusion without a plate, 2 months after surgery

pins inserted in the adjacent vertebral bodies on which distraction can be applied. After release, the graft gets compressed and stabilized in place within the intervertebral space (Fig. 3). In the plate group, an anterior interlocking cervical spine plate was added. Wound closure is performed after insertion of a haemovac and meticulous haemostasis.

Results

The mean duration of surgery was 90 min (range 70–120 min) without plate and 105 min (range 50–150 min) with plate.

Average follow-up time was 34 (range 22–46) months. The follow-up examination was performed by an indepen-

dent examiner unrelated to the surgeon's institution. After assessment of each patient's postoperative history, clinical examination and flexion/extension radiographs were performed.

Pain

Four patients in the plate group and eight patients in the non-plate group complained of permanent pain, but the intensity decreased from 8.7 to 3.8 on the visual analogue scale in the plate group and from 8.4 to 4.4 in the non-plate group (Table 1). There was a significant reduction in pain in both groups ($P=0.0001$), but there was no signifi-

Table 1 Pain and neurological outcome (VAS visual analogue scale)

	Plate (n=24) Pre/postoperatively	No plate (n=26) Pre/postoperatively	Postoperative difference P-value
Pain (VAS 0–10)	8.7/3.8	8.4/4.4	0.8015 ns
Pain medication (patients)	22/5	26/8	0.1434 ns
Sensory deficit (patients)	21/7	17/9	0.076 ns
Motor weakness (patients)	9/3	7/2	0.3753 ns
Reflex difference (patients)	13/0	6/3	0.0461*

* $P < 0.05$

cant difference between the groups ($P=0.80$). Only five patients in the plate group and eight in the non-plate group used regular medication ($P=0.14$).

Neurology

Disturbances of sensibility were noted in seven patients in the plate group and in nine in the non-plate group. A trend of significant improvement is seen in the plate group ($P=0.08$).

Motor weakness attributable to neural dysfunction was found in three patients in the plate group and in two patients in the non-plate group (Table 1). There is no statistical difference in improvement between the two groups ($P=0.38$). A significant difference is seen in changes in the reflexes: no patient showed asymmetry of reflexes in the plate group, while three remained with pathological findings in the non-plate group ($P=0.05$). There was no postoperative deterioration in the neurological status.

Functional assessment

Only six patients in the plate group and five in the non-plate group had severe restriction in flexion (chin-sternum distance >3 cm), which was not a statistical difference ($P=0.86$). Severely restricted extension (chin-sternum distance <15 cm) was found in six patients in the plate group and in five in the non-plate group, which again is not a statistical difference ($P=0.15$). Similar findings were noted in the rotation measurements, with no significant differences between the groups in neutral position ($P=0.16$), flexed position ($P=0.77$) and extension ($P=0.73$). The range of motion improved significantly in both groups ($P=0.001$), but with no differences between the groups ($P=0.85$).

Radiological assessment

The evaluation of fusion was carried out with the functional radiographs at follow-up examination (Table 2). The criteria for solid bony union was no motion between flexion and extension as well as homogeneous bone formation in the intervertebral space and incorporation of the

Table 2 Results of the radiological assessment of the 72 fused segments, by group

		Plate group (35 segments)	No-plate group (37 segments)
Fusion	Solid	27	28
	Probable	7	6
	Pseudarthrosis	1	3
Graft	Dislocation >2 mm	0	3
	Loss of height >2 mm	0	2

bone graft. Probable fusion was recorded when there was no apparent motion on flexion/extension radiographs, there was a satisfactory clinical result, but there was no evident bridging of trabeculae. In the plate group, 19 patients showed a solid bony union (in spite of one plate breakage), in four patients the union was probable and one patient had a reintervention for pseudarthrosis and was fused at follow-up. In the no-plate group, 20 patients showed a solid bony union, four a probable union and two were reoperated for pseudarthroses. These results showed no statistical differences between the two groups concerning solid fusion ($P=0.29$). The graft height and dislocation was assessed. In two patients in the no-plate group, the graft moved ventrally by more than 2 mm, and in three the loss of height was more than 2 mm. The average change in the angle of the endplates of the adjacent vertebrae showed no significant difference between the two groups, remained at 5.8° for the plate group and changing from 5.4° to 5.2° on average for the no-plate group. The comparison of the graft quality (height, dislocation) of the two groups showed significantly better results for the plate group (Mann-Whitney U test: $P=0.04$).

Other outcome variables evaluated by questionnaire

At follow-up, three patients with a plate and nine without a plate were unable to work. (Preoperatively there were 11 patients with in the plate group and 13 in the no-plate group unable to do their work.) Eleven patients with a plate and 18 with no plate sought help from their doctor outside of the postoperative routine check-ups (at 6 weeks and 3–4 months). Twelve patients with a plate (50%) re-

quired no more than nine sessions of postoperative physiotherapy, while only eight without a plate (36%) were satisfied with the same amount of physiotherapy. At follow-up, 13% of patients with a plate ($n=3$) and 32% without a plate ($n=7$) were still dependent on physiotherapy.

Complications

Intraoperative complications occurred twice in a plate procedure: one (transient) palsy of the recurrent nerve in the plate group and one excessive haemorrhage from the epidural veins during a two-level decompression. In the postoperative course a plate fracture was noted; however, pain was minimal and reintervention was declined. At follow-up, a solid fusion was radiographically verified. A patient without a plate showed a painful haematoma at the iliac donor site, and secondary wound closure was required. Two patients in the no-plate group complained of prolonged discomfort during swallowing, but no treatment was necessary. Pseudarthrosis was obvious in one patient with a plate, and required posterior additional fusion. Two patients with two-segment fusions in the group with no plate also showed non-union and required reintervention for final stabilization.

Discussion

Disc protrusions, degenerative changes of facet joints or the uncinata process may be involved as compressive structures causing painful syndromes and/or neurological symptoms. Most anterior decompressive procedures require removal of the disc for adequate decompression. However, as intervertebral discs are part of the structure of the anterior column of the cervical spine, removal for decompressive procedures creates deficiency of the anterior column, to which the spine has to adapt, unless replaced by appropriate material. Autologous bonegraft from the iliac crest is the material of preference, but substitution with homograft or allograft has also been reported with satisfactory results [7,16].

Of major concern with regard to anterior interbody fusion in the cervical spine is the immediate postoperative stability of the bone graft and the rate of pseudarthrosis.

The dislocation of the graft is partially prevented by the local tension of the surrounding tissue (if inserted under distraction) increasing the friction forces of the decorticated endplates. Some authors prefer to increase stability by molding the graft appropriately [1, 4, 13,14], thus preventing graft migration postoperatively. In spite of these precautions, the rates of pseudarthrosis and graft collapse are reported to increase with the number of segments fused [1]. Therefore, the use of plates became popular to avoid these failures [10]. An increased stability with plates has been shown in several *in vitro* and *in vivo* stud-

ies [5,6], leading to a wide use of anterior instrumentation.

The focus of this study was on the use of plates in anterior fusions of the cervical spine. Based upon previous studies of extensive decompression and multisegmental fusion, increased fusion rates are provided by application of internal fixation [1, 8, 9, 11,12]. However, in mono- or bisegmental anterior fusion after decompression for degenerative conditions, the additional use of a plate remains controversial, and to our knowledge few prospective studies have been recently published [6,17]. Confirming the results of these studies, the clinical and radiological results of our prospective investigation suggest that the use of plates does not provide superior results. Accordingly, the indication for plates in degenerative conditions of the cervical spine requiring anterior fusion to the following parameters should be restricted to special conditions such as increased instability, insufficient bone quality or inappropriate graft size. Loss of resistance and secondary development of kyphotic deformity may be avoided by using plates. Although the significance of segmental loss of lordosis is not known, the use of plate allows maintenance of physiological lordosis [17], and therefore contributes to favourable long-term results. If there is any doubt about the remaining stability of the fused segment in post-traumatic cases or tumours, or after reducing deformities, an additional plate has to be considered to improve the fusion rate. According to the literature, the rate of pseudarthrosis increases with an increase in the number of segments fused [1]. Therefore, fusion over more than two segments remains an indication for instrumentation until proven otherwise.

Based upon the neurological assessment, there was a similar improvement in sensory deficits and muscle weakness in both groups; however, reflex asymmetry normalized significantly better in the plate group. The reason for this difference remains unclear.

Plates with interlocking mechanisms for the screws were used in order to avoid screw loosening [8,10]. The result might theoretically be affected by the choice of implant. However, since all patients received the same type of plate, comparability is maintained.

The rate of complications in both groups is comparable. However, both pseudarthroses in the no-plate group occurred in two-segment fusions. It remains to be seen whether there is a difference between the groups when mono- and bisegmental fusions are analyzed separately. The study of Zoëga et al. [17] suggests that the outcome of bisegmental fusions with a plate might favourably influence the results.

The clinical results concerning pain were the same for both groups in our study, in contrast to the results of Zoëga et al. [17] indicating that anterior plate fixation leads to better clinical results.

We are aware of the problem of the relatively low number of the patients involved in the study affecting the

statistical power. However, this disadvantage may be outweighed by the advantages of the homogeneity of the groups: there was only one surgeon, using an identical strategy, surgical indication, and surgical procedure, and the same postoperative treatment in all cases. This resulted in a high degree of comparability between the groups.

The distribution of the patients between the groups was conducted according to the chronological admission to the hospital. Even if this procedure does not represent true randomization, the administrative process for hospitalization was organized by a non-medical staff member of the hospital administration, who had no influence over the selection of patients. Therefore, unbiased enrollment was guaranteed.

Conclusions

The results of our prospective study, comparing anterior cervical fusion with and without a plate, do not support the general use of anterior plates in degenerative conditions. The total neurological and pain score improved significantly in both groups, with the changes being greater in the group with plates. There was no significant differences between the groups regarding fusion grading, but graft quality (height of graft, dislocation, resorption) was significantly better in the plated group. Pain, postoperative motion and complication rates did not differ between the two groups.

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