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Can Self-Locking Cages Offer the Same Clinical Outcomes as Anterior Cage-with-Plate Fixation for 3-Level Anterior Cervical Discectomy and Fusion (ACDF) in Mid-Term Follow-Up?

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Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Background: Self-locking stand-alone cages (MC+) and cage-with-pate fixation system are 2 different surgical methods used in anterior cervical discectomy and fusion (ACDF), but few systematic comparative studies comparing the 2 methods in treating multilevel cervical spondylotic myelopathy (MCSM) have been published.

Material/Methods: Sixty-two patients with MCSM who underwent multilevel ACDF were enrolled and completed at least a 3-year postoperative follow-up. The operative time, intra-operative blood loss, and clinical and radiological results were compared between the MC+ self-locking cages group and the cage-with-plate fixation group. Clinical parameters, including VAS for neck pain, Japanese Orthopedic Association (JOA) score, and neck disabled index (NDI), were evaluated. Surgical results according to Odom's criteria and postoperative dysphagia status, C5 nerve root palsy, and loosening of the instrumentation were recorded. Postoperative radiological results, including fusion rates, fusion segmental Cobb's angle (FSC), cervical lordosis, fusion segmental height (FSH), cage subsidence, and adjacent segment degeneration, were assessed.

Results: The VAS score, JOA score, and NDI score were significantly improved in both groups. However, the patients in the cage-with-plate group were more likely to have neck pain at the last follow-up. The cervical lordosis, FSC, and FSH showed significant correction immediately after surgery. The loss of the cervical lordosis and FSH were higher in the MC+ group.

Conclusions: We found that use of MC+ cages is safe and effective in treating MCSM, but for patients who require strong postoperative stabilization and maintaining the cervical alignment better, the cage-with-plate fixation may best.

MeSH Keywords: **Retrospective Studies • Spinal Cord Compression • Spondylosis • Technology, Radiologic • Treatment Outcome**

Abbreviations: **NDI** – Neck disability index; **ACDF** – anterior cervical discectomy and fusion; **PEEK** – polyetheretherketone; **MCSM** – multilevel cervical spondylotic myelopathy; **VAS** – visual analogue scale; **JOA** – the Japanese Orthopedic Association score; **FSC** – fusion segmental Cobb's angle; **FSH** – fusion segmental height; **ROM** – range of motion; **TAVBH** – total anterior vertebral body height; **ADH** – anterior disc height; **MDH** – midline disc height; **PDH** – posterior disc height; **mDH** – mean disc height; **ASD** – adjacent segment degeneration; **CSF** – cerebrospinal fluid

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Background

Anterior cervical discectomy and fusion (ACDF) remains the criterion standard for the surgical management of cervical degenerative disc disease [1]. In order to enhance the cervical stability, fusion rate, and cervical curve correction, titanium plates are widely used in ACDF [2,3]. However, anterior surgery with a plate may also be associated with disadvantages and complications, such as loosening of screws, trachea-esophageal injury, postoperative dysphagia, or neurovascular structural injuries, especially in the multilevel ACDF, which may need wide surgical exposure with consequent visceral retraction and accelerated adjacent segmental degeneration [4]. The self-locking cage (MC+, LDR, France) is a new cervical fusion system recently introduced in cervical spine surgery; it is reported to limit the potential risk of the drawbacks and complications associated with traditional anterior cervical plates [5]. It is convenient to use and can avoid implant contact with the anterior soft tissue, reducing the risk of trachea-esophageal injury [6,7]. The whole device is composed by an interbody spacer and self-locking devices, which limits the risk of cage migration and increases the rigidity of the fusion construct, and provides adequate stability through inserting the spacer into the endplates of the lower vertebral body [8]. Clinical reports on the use of these devices for ACDF mainly focused on one- or two-level cervical spondylotic myelopathy, which showed satisfactory clinical and radiological results [6,9]. Few studies have been published on the application at 3 or more levels. Furthermore, there is still controversy about the clinical efficacy and satisfactory radiological outcomes between the use of this kind of self-locking cages and the cage-with-plate fixation in multilevel ACDF. Whether the self-locking cage has the same biomechanical and clinical stability as plate fixation did is unclear. The aim of this study was to retrospectively evaluate the clinical and radiological outcomes of ACDF for multilevel cervical spondylotic myelopathy (MCSM) using self-locking stand-alone polyetheretherketone (PEEK) cages compared with using cage-with-plate fixation in patients with at least 3-year postoperative follow-up. We analyzed the clinical efficacy and complications of these 2 surgical approaches in treatment of MCSM for the mid-term follow-up; compared radiological changes in cervical sagittal alignment and clinical stability (curvature, range of motion, fusion segment height, fusion rate, and subsidence rate); and explored the indications for the application of the self-locking cage.

Material and Methods

Patient General Information and Indications

This retrospective study was approved by the Institutional Committee for Clinical Studies and the requirement for informed consent was waived. This retrospective study included 62 patients treated by ACDF for MCSM in our hospital from Jan 2013 to Jan 2014 by the same spine surgery team. The subjects were divided into a MC+ self-locking group (MC+, LDR, Troyes, France) and a cage-with-plate fixation group (Reflx Hybrid, Stryker, USA). We included 30 patients with a mean age of 56.6±12.6 years old (range 43–75 years, average 56.6 y, 12 males, 18 females) in the MC+ self-locking group and the levels to be treated included C3–C6 (19 patients) and C4–C7 (11 patients). The cage-with-plate group included 32 patients with a mean age of 55.3±11.3 years (range 41–78 years, average 55.3 y, 18 males, 14 females), and the levels to be treated included C3–C6 (17 patients) and C4–C7 (15 patients). All patients had at least 3 years' postoperative follow-up. All the medical records and imaging studies were analyzed retrospectively. The protocols and procedures for the protection of human subjects were approved by the Ethics Committee of Beijing Tiantan Hospital, and all the methods were carried out in accordance with approved guidelines.

Inclusion criteria were: (1) cervical myelopathy diagnosed by symptoms, physical examination, cervical X-ray, computed tomography (CT) scan, and magnetic resonance imaging (MRI) with unsatisfactory conservative treatment; (2) spinal cord ventral compression mainly caused by 3 levels cervical disc herniation visible on MRI. Exclusion criteria were: (1) progressed stenosis, ossification of posterior longitudinal ligament (OPLL), cervical trauma, tumor, or infection; (2) impossible to accomplish decompression though ACDF; (3) neck or cervical operation history; and (4) incomplete clinical imaging records.

The MC+ device is made of PEEK. The upper convex part of the MC+ cage is located in the frontal and sagittal planes. It can be used for rebuilding proper intervertebral height and cervical lordosis. The MC+ cage is composed of an interbody spacer and a titanium clip, which is inserted into the lower endplate after implantation for fixation.

Surgical procedure

The same experienced spine surgeon performed all operations in Beijing Tiantan Hospital. All patients were supine after anesthesia, and a Smith-Robinson incision was made anteriorly and overlying the medial border of the sternocleidomastoid muscle at the level of the degenerated intervertebral disc. The trachea and esophagus were retracted medially and the neurovascular bundle with the sternocleidomastoid muscle was retracted laterally. After fluoroscopic confirmation of the affected level, complete discectomy and decompression was performed. The compressive materials, including the intervertebral disk and osteophyte, were removed. The posterior longitudinal ligament was opened, and other compressive elements were removed to ensure adequate dural and neural decompression. The cervical column was placed in physiologic lordosis with the

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use of a Caspar screw distractor. The endplates are abraded before fusion by removing the cartilaginous tissue from the endplates using surgeon-preferred tools such as rongeurs, curettes, or shaving spatulas. Only the cartilaginous portion of the vertebral endplate is removed, and the bony endplate is preserved as much as possible to prevent cage subsidence. For the cage-with-plate fixation group, PEEK cages and plating systems (Reflx Hybrid, Stryker, USA) were used. For the MC+ (LDR, Troyes, France) group, MC+ cages were used. Before insertion, all cages were filled with artificial bone grafting material. A soft collar was given to all the patients after surgery with the fixation from 4 to 6 weeks.

Outcome assessment

Clinical and radiographic data analyses were performed separately by 2 independent experienced spine surgeons, and were routinely examined preoperatively, postoperatively, and at each follow-up visit (at 3 months and 3 years after surgery). The radiographic measurements were repeated 3 times and the results were averaged. Blinding was accomplished by removing identifying information on the radiographs and randomly assigning them to each examiner.

Clinical evaluation

All data were collected perioperatively, such as characteristics, blood loss volume, operative time, hospital stay, and drainage. The visual analogue scale (VAS) was used to evaluate neck pain level, while the Japanese Orthopedic Association score (JOA) and Neck Disability Index (NDI) were used to evaluate preoperative, postoperative, and last follow-up for neurological function. Overall patient satisfaction was assessed according to Odom's criteria [10] and was graded as satisfactory (excellent/good) or unsatisfactory (fair/poor) based on the improvements in clinical manifestations and the ability to regain physical activities. Odom's criteria were used for evaluation of the clinical results at 3-month postoperative and last follow-up. It was considered satisfactory if the evaluation was excellent or good based on Odom's criteria. Dysphagia-related symptoms were considered as none (no episodes of swallowing problems), mild (rare episodes of dysphagia), moderate (occasional swallowing difficulty with specific food), and severe (frequent difficult swallowing with majority of food) according to the Bazaz et al. grading system [11]. C5 nerve root palsy was defined as deltoid muscle strength decrease by 2 or more levels with or without sensory disorders of the shoulder and upper extremity, which can cause upper-extremity motor dysfunction [12].

Radiological evaluation

Radiological evaluation included standard anteroposterior, lateral, flexion–extension radiographs, and multiplanar reconstructed CT, which were acquired before surgery, at 3 months, and at the last follow-up after surgery. CT scan reconstructions were performed at last follow-up to assess fusion rate if fusion could not be confirmed by radiographs. Radiological measurements were made using PACS software (LPacs system, Beijing, China).

Cervical lordosis (C2–C7) was defined by the Cobb's angle formed by the upper endplate of C2 and the lower endplate of C7 on lateral radiograph in neutral position preoperatively and at each follow-up appointment [13]. The range of motion (ROM) of the cervical spine was defined as the difference between C2–C7 Cobb's angle measured on the flexion and extension radiographs. The fusion segmental Cobb's angle (FSC) was defined as the Cobb's angle formed by the upper endplate of the upper vertebral body and the lower endplate of the lower vertebral body of the fusion levels. The fusion segmental height (FSH) was determined as the distance from the midpoint of the upper endplate of the upper vertebral body to the midpoint of the lower endplate of the lower vertebrae in the operated levels. Loss of cervical lordosis, FSC, ROM, and FSH were defined as the difference in the measurement data between 3-months postoperative and the last follow-up. The criteria for fusion were: (1) the motion of adjacent spinous processes is not over 2 mm on flexion – extension lateral radiographs; (2) radiolucent gap between cage and endplate is not found; and (3) continuous bridging trabeculae is formed between cage and endplate [14]. Fusion rate=amounts of fusion levels/all the operation levels*100%. To assess the occurrence of subsidence, we used as reference measurement the total anterior vertebral body height (TAVBH). The anterior, midline, and posterior disc height (ADH, MDH, and PDH, respectively) were measured and averaged to determine a mean disc height (mDH). The ratio was calculated (mDH/TAVBH) at early and last follow-up. Given that the 2 vertebral bodies, heights were controlled as a constant, a decrease of mDH leading to a variation of the ratio greater than or equal to 10% was considered as significant subsidence [15,16] (Figure 1). Subsidence rate=subsidence levels/all the operation levels*100%. Adjacent segment degeneration (ASD) was defined as new osteophyte formation or enlargement, new narrowing of the intervertebral disc space, or increase of the anterior longitudinal ligament above and below fused segments. Screw loosening was defined as a more than 1-mm radiolucent zone surrounding the screw based on the anteroposterior and lateral plain radiography [17].

Statistical analysis

SPSS 17.0 software (IBM, Armonk, New York, USA) was used for statistical analysis. Measurement data are expressed as mean±standard deviation; count data were presented as percentage. The *t* test was used to compare patient parameters between 2 groups, including age, disease course, pre- and

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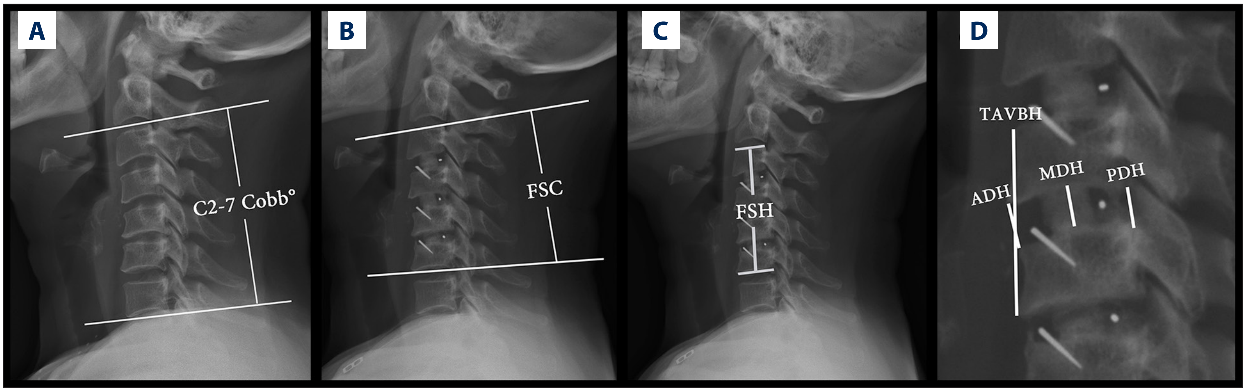

Figure 1. Radiological measurements on X-ray graphs. (**A**) The measurement method for C2–C7 Cobb's angle: the angle formed by the upper endplate of C2 and the lower endplate of C7 on lateral radiograph in neutral position. (**B**) FSC: the angle formed by the upper endplate of the superior vertebrae body and the lower endplate of the inferior vertebrae body in the operated levels in neutral position. (**C**) FSH: the distance from the midpoint of the upper endplate of the upper vertebral body to the midpoint of the lower endplate of the lower vertebral body in the operated levels. (**D**) mDH/TAVBH: mDH was defined as the mean value of ADH, MDH and PDH. TAVBH: total anterior vertebral body height.

Table 1. Pre-operative clinical data of the 2 groups of patients.

	MC+ group	Cage-with-plate group	P value
Sex (Male/Female)	16/14	18/14	0.818
Age (years)	56.6±12.6	55.3±13.1	0.692
Course of disease (months)	10.5±5.70	11.3±6.20	0.599
Pre-op Neck pain VAS scores	4.1±1.52	4.1±1.50	1
Pre-op JOA scores	8.3±2.17	7.9±2.45	0.625
Pre-op NDI scores	32.3±9.32	30.1±8.45	0.745

JOA – Japanese Orthopedic Association.

postoperative VAS, JOA score, NDI score, pre- and postoperative C2–C7 Cobb's angle, FSC, ROM, and FSH. The chi-square test was used to assess the fusion rate, subsidence rate, the incidence of dysphagia and ASD, and was considered statistically significant at $p<0.05$.

Results

Clinical outcome

All 62 patients (30 men and 32 women) were followed-up, including 30 in the MC+ self-locking group and 32 in the cage-with-plate fixation group. The mean age at surgery was 55.9±8.6 years (range, 41–78 years). The general demographics and group distribution are shown in Table 1. There was no significant difference between 2 groups preoperatively in age, sex, operative levels, course of disease and pre-operative VAS, JOA, or NDI score ($p>0.05$). The operative time was shorter in the MC+ group (100.8±24.22 min) compared with the cage-with-plate fixation group (130±18.13 min) ($p<0.05$). The blood loss in the corresponding groups was 29.6±9.82 and 30.5±11.63 ml, respectively. The corresponding postoperative drainage was 25.3±19.83 ml and 26.5±18.01 ml, respectively. The hospital stay was 6.2±0.72 d and 6.3±0.52 d, respectively. There was no difference between the 2 groups in blood loss, postoperative drainage, or hospital stay ($p>0.05$).

According to the Odom criteria, the percentages of patients with excellent and good clinical outcomes were 96.7% in the MC+ group and 93.8% in the cage-with-plate group at the 3-months postoperative follow-up, and at the last follow-up, the corresponding percentages of excellent and good clinical results were 90% and 90.6%, respectively. There was no difference at each time point ($p>0.05$). Significant improvements were found in the VAS, JOA, and NDI score at 3-month and 3-year follow-up after surgery compared with those measured preoperatively in both groups. Concerning the neck pain VAS score, the pre-operative, 3-month, and 3-year postoperative values were 4.1±1.52, 1.7±1.21, and 2.5±1.25, respectively, in the MC+ group, and 4.1±1.50, 1.6±1.03, and 0.9±1.32, respectively, in the cage-with-plate group. The neck pain VAS score

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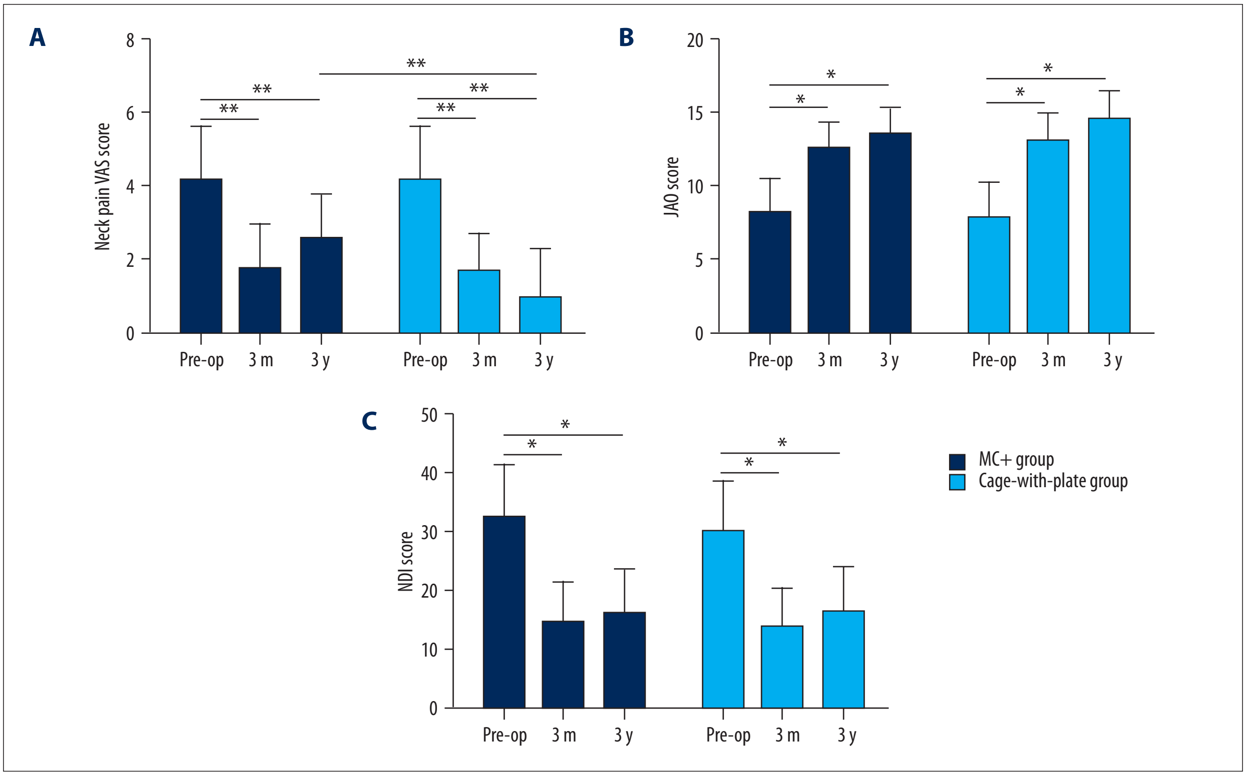

Figure 2. (**A–C**) The clinical outcomes. Asterisk (*) indicates statistically significant compared with pre-operative or the other group values (p<0.05). Pre-op – pre-operation; 3 m – 3 months postoperatively; 3 y – 3 years postoperatively.

was more pronounced in the MC+ group (2.5±1.25) than in the cage-with-plate group (0.9±1.32) at 3-year postoperative follow-up (p<0.05). Although the postoperative NDI and JOA score in both groups improved significantly (p<0.05) compared with pre-operative measurements, there were no significant differences in the JOA score or NDI score between the 2 groups at each time point (p>0.05) (Figure 2, Table 2).

Radiological evaluation

In the MC+ group the C2–C7 Cobb's angle was 10.3±8.91° before surgery, 19.4±7.72° at 3 months after surgery, and 15.5±5.93°at the final follow-up examination, whereas in the cage-with-plate group, the angle was 10.5±8.55° before surgery, 22.2±6.44° at 3 months after surgery, and 20.4±7.32° at last follow-up. The C2–C7 Cobb's angle improved significantly at 3-month and at the last follow-up examination compared with that before surgery in the 2 groups (p<0.05). Concerning the ROM of cervical spine, the pre-operative, 3 months, and the last follow-up postoperative values were 31.6±9.80°.,23.3±5.67°, and 21.8±5.33°, respectively, in the MC+ group and 32.3±10.36°, 21.0±6.57°, and 20.2±6.64°, respectively, in the cage-with-plate group. The cervical spine ROM decreased significantly at 3-month and last follow-up examination in both groups (p<0.05). In the MC+ group, the FSH increased from 74.1±9.54 mm preoperatively to 80.4±7.82 mm postoperatively at 3 months after surgery and 77.4±6.17 mm at the last follow-up. In the cage-with-plate fixation group, FSH increased from 73.2±8.62 mm preoperatively to 81.5±7.73 mm postoperatively at 3 months and 81.1±8.15 mm at the last follow-up. The pre-operative FSH improved significantly after surgery at 3 months and last follow-up postoperatively in both groups (p<0.05). The FSC was 5.3±5.28° preoperatively, 11.7±3.92° at 3 months after surgery, and 9.5±4.33° at the last follow-up in the MC+ group. FSC of the cage-with-plate group was 4.7±4.83° before surgery, 11.2±5.46° at 3 months after surgery, and 10.1±3.71° at the last follow-up. The pre-operative FSC improved significantly at 3 months and last follow-up postoperatively in both groups (p<0.05). There were no significant differences in these parameters between the 2 groups at each time point (p>0.05). The loss of the C2–C7 Cobb's angle was more pronounced in the MC+ group (3.9±2.25°) than in the cage-with-plate group (1.8±1.57°) at last follow-up postoperatively (p<0.05). The loss of FSH was also more pronounced in the MC+ group (3.0±2.30 mm) than in the cage-with-plate group (0.4±2.61 mm) at last follow-up (p<0.05), but the loss of ROM and FSC had no obvious differences at the last follow-up between the 2 groups. (p>0.05). The subsidence of the MC+ group and cage-with-plate fixation group were 18.8% (17/90) and 8.3% (8/96), respectively, at the last follow-up. The occurrence of subsidence between the 2 groups was significantly different (p<0.05). At 3 years after surgery, the occurrence of

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Table 2. The clinical outcomes measured before operation and during follow-up of the 2 groups.

Parameters	MC+ group (n=30)	Cage-with-plate group (n=32)	P value
Operative time (min)	100.8±24.22	130±18.13	<0.001
Blood loss (ml)	29.6±9.82	30.5±11.63	0.744
Hospital stays (d)	6.2±0.72	6.3±0.55	0.54
Drainage (ml)	25.3±19.83	26.5±18.01	0.803
Excellent/Good rate according to Odom's criteria			
Postoperative 3 months	96.7% (29/30)	93.8% (30/32)	0.593
Last follow-up	90% (27/30)	90.6% (29/32)	0.934
Operated levels			
C3–C6	19	17	0.416
C4–C7	11	15	
Neck pain VAS scores			
Pre-op	4.1±1.52	4.1±1.50	1
3-month follow-up	1.7±1.21*	1.6±1.03*	0.727
Last follow-up	2.5±1.25*	0.9±1.32*	<0.001
JOA scores			
Pre-op	8.3±2.17	7.9±2.45	0.5
3-month follow-up	12.6±1.89*	13.0±2.01*	0.423
Last follow-up	14.5±1.78*	14.6±1.93*	0.833
NDI scores			
Pre-op	32.3±9.32	30.1±8.45	0.333
3-month follow-up	14.4±7.13*	13.6±6.67*	0.65
Last follow-up	15.9±7.64*	16.2±7.96*	0.88
Dysphagia rate (%)	6.7% (2/30)	31.2% (10/32)	0.014
C5 nerve root palsy rate (%)	3.3% (1/30)	6.2% (2/32)	0.593
Loosen of instrumentation rate	0	3.1% (1/32)	0.329
Adjacent segment degeneration	3.3% (1/30)	6.3% (2/32)	0.63

* $p<0.05$ compared with pre-operative.

fusion was investigated, showing 93.3% (84/90) in the MC+ group and 94.7% (91/96) in the cage-with-plate group. The fusion rate showed no statistical difference between the 2 groups ($p>0.05$). (Figure 3, Table 3)

According to diagnosis of adjacent segment degeneration criteria, 1 patient had upper adjacent level degeneration in the MC+ group at the last follow-up, of which the degeneration rate was 3.3% (1/30). In the cage-with-plate group, there were 2 patients who had upper adjacent levels degeneration, of which the degeneration rate was 6.3% (2/32). There was no significant difference in the incidence of adjacent segment degeneration between the 2 groups ($p>0.05$).

Complications assessment

No neurological deterioration happened after surgery in any patients. In addition, there were no device failures, cerebrospinal fluid (CSF) leakage, or superficial or deep wound infections at the cervical wound. According to Bazaz criteria, the incidence

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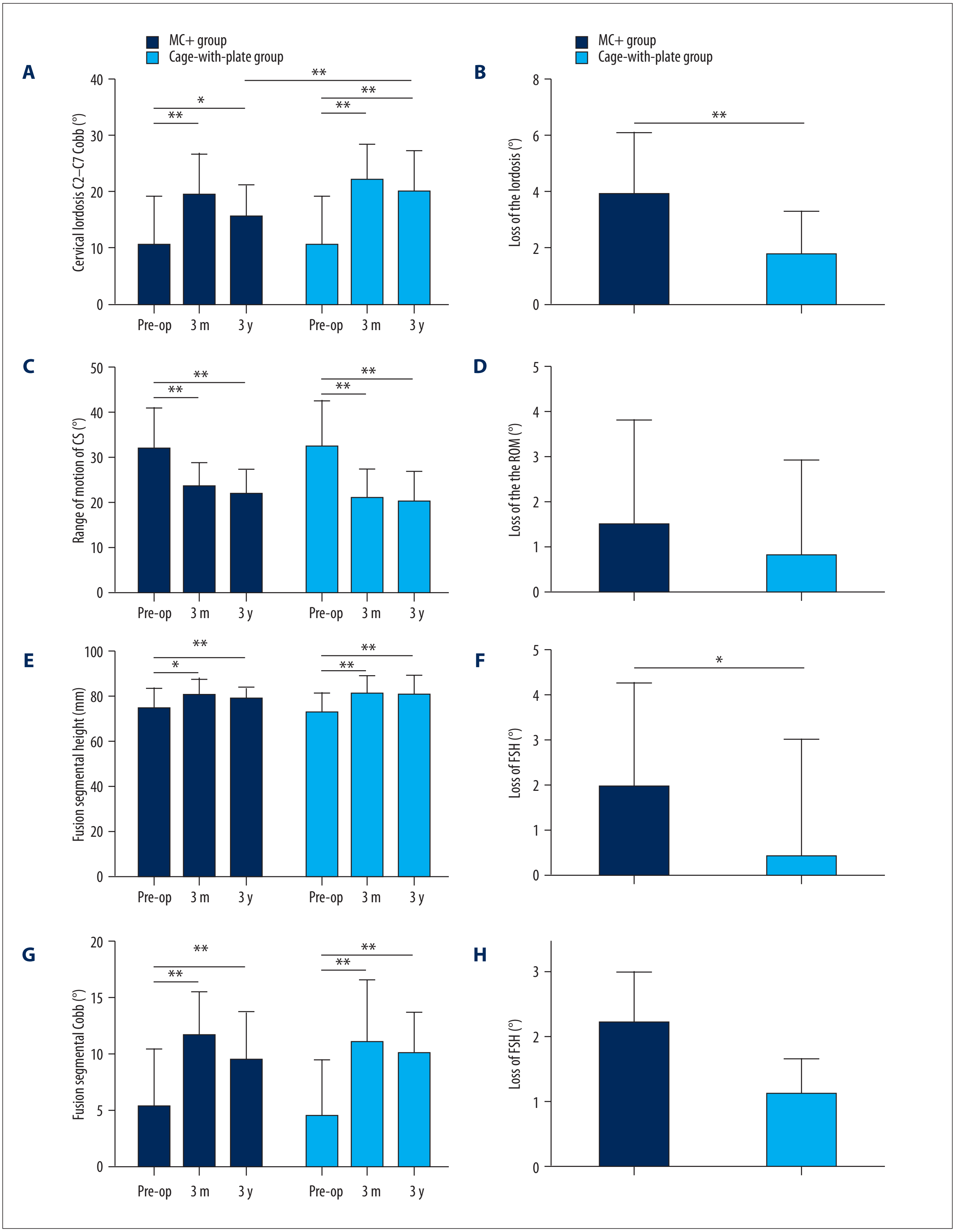

Figure 3. (**A–H**) The radiological outcomes. Asterisk statistically significant compared with pre-operative or the other group values ($p<0.05$). Pre-op – pre-operation, 3 m – 3 months postoperatively, 3 y – 3 years postoperatively

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Table 3. The radiological parameters measured before operation and during follow-up of the 2 groups.

Parameters	MC+ group (n=30)	Cage-with-plate group (n=32)	P value
Cervical lordosis (C2–C7 Cobb) (°)			
Pre-op	10.3±8.91	10.5±8.55	0.929
3-month follow-up	19.4±7.72*	22.2±6.44*	0.125
Last follow-up	15.5±5.93*	20.4±7.32*	0.005
Loss of Lordosis	3.9±2.25	1.8±1.57	<0.001
ROM of cervical spine (°)			
Pre-op	31.6±9.80	32.3±10.36	0.786
3-month follow-up	23.3±5.67*	21.0±6.57*	0.146
Last follow-up	21.8±5.33*	20.2±6.64*	0.302
Loss of ROM	1.5±2.31	0.8±2.15	0.221
FSH (mm)			
Pre-op	74.1±9.54	73.2±8.62	0.698
3-month follow-up	80.4±7.82*	81.5±7.73*	0.58
Last follow-up	78.4±6.17*	81.1±8.15*	0.149
Loss of FSH	2.0±2.30	0.4±2.61	0.013
FSC (°)			
Pre-op	5.3±5.28	4.7±4.83	0.642
3-month follow-up	11.7±3.92*	11.2±5.46*	0.682
Last follow-up	9.5±4.33*	10.1±3.71*	0.559
Loss of FSC	2.2±0.82	1.1±0.55	0.275
Fusion rate (%)	93.3% (84/90)	94.7% (91/96)	0.673
Cage subsidence rate (%)	18.8% (17/90)	8.3% (8/96)	0.035

ROM – range of motion; FSH – fusion segmental height; FSC – fusion segmental Cobb's angle. * $p<0.05$ compared with pre-operative.

of dysphagia was evaluated immediately after surgery. The difference in dysphagia rate between the 2 groups was statistically significant ($p<0.05$). The incidence of dysphagia in the MC+ group was approximately 6.7% (2/30). All patients had mild dysphagia immediately after surgery and all recovered within 3 months, while the incidence of dysphagia in the cage-with-plate group was approximately 31.2% (10/32). Nine patients had mild dysphagia immediately after surgery, whereas the remaining 1 patient reported regression of symptoms after 6 months. After conservative treatment, 9 patients recovered after 3 months, and 1 patient recovered after 12 months. Neither long-term nor severe dysphagia was observed.

The incidence of C5 nerve root palsy in the MC+ group was approximately 3.3% (1/30), while the incidence in the cage-with-plate group was 6.2% (2/32). The difference in C5 nerve root palsy rate between the 2 groups was not statistically significant ($p>0.05$). In this study, C5 nerve root palsy occurred within 4 days postoperatively, with unilateral onset. It generally began to lessen by 7 days after surgery and the average recovery time was 20 days. All patients underwent conservative treatment once symptoms were found.

Discussion

Anterior cervical discectomy and fusion (ACDF) offers direct removal of the pathologic lesion and correction of kyphotic cervical deformity, with satisfactory fusion rate and clinical outcome for cervical spondylotic myelopathy (CSM) [18]. However, surgical management of multilevel cervical spondylotic myelopathy (MCSM) is complicated and remains a matter of controversy [19,20]. It is reported that ACDF with a long anterior plate is a reliable and effective method to treat MCSM. The disadvantage is that ACDF with plate damages extensive areas of soft tissue, leading to a higher incidence of dysphagia, loss of cervical motion, adjacent segment degeneration, and hoarseness [4]. Therefore, some surgeons prefer

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using posterior surgery for decompression, including laminectomy and laminoplasty, which creates more space posteriorly for the spinal cord [21]. The major disadvantages include progressive kyphosis, axial neck pain, and C5 nerve root palsy, which have limited its use [22].

To avoid these complications, a new type of cervical anterior cervical fusion system (Zero-track self-locking fusion device, MC+, France, LDR) has been clinically applied. It has been proved in previous studies that ACDF with self-locking cages can be a safe and effective procedure and offers good clinical outcomes in 1- and 2-level procedures [23,24]. However, some biomechanics research shows that the self-locking cage provided equal biomechanical stability to using an anterior plate with cages in 1- or 2-level ACDF, but in 3-level or more ACDF, the locking plate and cage construct was stiffer than the self-locking devices [25]. Some clinical outcomes of 3-level ACDF with self-locking cages have shown that it also can get achieve good clinical outcomes in short-term follow-up [26,27]. It is still controversial whether the self-locking cages can achieve similar clinical outcomes and stabilization as found with plate fixation, and the incidence of complications in mid- or long-term follow-up is unclear in treating MCSM.

Successful treatment with ACDF depends on adequate decompression and achieving a high fusion rate with low rate of complications [28]. However, the fusion rate was reported to decrease as the number of levels increases, even when an anterior cervical locked plate was used [29]. In this study, excellent fusion rates were observed in the cage-with-plate group and in the MC+ group, and there was no significant difference between the 2 groups. This demonstrates that ACDF using self-locking cages for MCSM can achieve a similar fusion rate as the cage-with-plate system. Surgical skills and the design of the MC+ cage may contribute to the good fusion rate. The former includes proper graft bed preparation and intervertebral space distraction, as well as the shape of the MC+ cage, which is designed so that the upper convex part is in the frontal and sagittal planes. This design makes the grafting space wider and tightens the contact of the endplate bone with the implant. All these factors ensure the stable reconstruction and earlier fusion.

Another key point to anterior cervical surgery is to restore and maintain intervertebral height and cervical alignment [30]. Bartels et al. found that use of cages in ACDF contributes to rebuilding intervertebral space height and enlarging the intervertebral foramen, which indirectly leads to nerve root decompression [31]. Furthermore, cages help reconstruct the cervical curve because it is designed with the height of cage decreasing from anterior to posterior. Cage subsidence can decrease the volume of intervertebral foramen pseudarthrosis formation and cervical alignment loss [32]. In our research, the cervical curve and FSH of the 2 groups improved at each follow-up compared with before surgery. However, in the MC+ group, the loss of cervical curve and fused segmental height were more obvious at the last follow-up. We found that 17 of the 90 (18.8%) inserted MC+ cages had subsided, with a statistically significant difference from the cage-with-plate group (8.3%). Reports on the occurrence rate of subsidence after ACDF have varied from 5.4% to 55.6%, depending on surgical methods [18,33]. The incidence of subsidence in the present MC+ series can explain the loss the cervical sagittal profile until the end of follow-up. One explanation for reduced subsidence is that the force was conducted through the anterior plate with less contact stress at graft/bone interfaces. The plate curve helps to preserve the loss of global cervical lordosis and the FSH with the prevention of the cage subsidence during the process of fusion. It may suggest that cage-plate fixation has advantages in maintaining cervical curve and stability over MC+ cages in postoperative and long-term effects.

Dysphagia is a concern after anterior cervical plating due to prolonged intra-operative esophageal retraction and/or due to the local postoperative plate prominence, especially with long plates in conjunction with multilevel ACDF [2,33,34]. The exact pathophysiologic mechanism of dysphagia remains unknown. In our study, the MC+ implant system demonstrated low rates of dysphagia (6.7%), with dysphagia rates as high as 31.2% in multi-level ACDF with anterior plating. Several studies suggest that the use of anterior locking plates is associated with higher incidence of dysphagia [35]. The shorter operation time and less blood loss of ACDF using self-locking stand-alone cages indicate less traction time and less damage of prevertebral soft tissues during surgery, which may contribute to the relatively low rate of dysphagia.

As for clinical outcomes, our findings are consistent with some previous studies in multi-level ACDF [36]. The neurological function improved due to complete decompression. No significant difference was found according to Odom's criteria between groups after surgery. Nevertheless, in our research, the neck VAS scores in the cage-with-plate fixation group were significantly lower than those in the MC+ group at the last follow-up. This can be explained by an imbalance of the cervical lordotic curve resulting from cage subsidence [37]. Regarding the relationship between subsidence and clinical outcome, Lee et al. reported that groups with high subsidence rates had poor clinical outcomes [38]. This indicates that the potential long-term drawbacks associated with subsidence should always be considered.

The ASD risk was reported to be higher in the cage-with-plate fixation group and a plate is likely to accelerate degenerative changes in adjacent segments [39]. Ji et al. hypothesized that the high ASD risk in the cage-with-plate fixation group

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was possibly due to increased fixation force, which then increased the level of stress generated in the adjacent intervertebral disks during cervical vertebra motion after surgery [40]. Furthermore, it has been reported that abnormal sagittal balance after ACDF promotes adjacent segment disease [41]. In our study, there was no statistically significant difference in ASD incidence between the 2 groups. Nevertheless, all patients remain under close observation for a longer follow-up.

Conclusions

Compared with cage-with-plate fixation for the treatment of multi-level cervical spondylopathy, the MC+ self-locking stand-alone cages can achieve similar surgical effects with the following advantages: easy operation, shorter operation time, and lower incidence of esophageal complications, and it also can restore the cervical lordosis and disk height. However, our study results suggest that the biomechanical stability of MC+ cages is not as good as cage-with-plate fixation in mid-term follow-up, and the drawbacks associated with postoperative cage subsidence and loss of cervical lordosis and fused segment height in patients with ACDF using MC+ cages should receive careful attention. For this reason, the decision to use a MC+ cage should be made carefully in treating cervical spondylotic myelopathy with cervical instability, cervical spondylopathy with cervical deformity, or cervical spinal cord injury without fracture or dislocation. Therefore, the cage-with-plate fixation should be used in patients who require strong postoperative motion stabilization. The present study also has several limitations. Firstly, a longer follow-up period would be needed to investigate adjacent segment degeneration and long-term cervical stabilization. Secondly, it was a retrospective study involving a small number of patients. We expect to perform a randomized prospective study with more patients included in the future.

Conflict of interests

None.

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