Single Level ACCF Combining Single Level Stand-alone ACDF in Treating Cervical Spondylotic Myelopathy

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Research article

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Abstract

Objective

Single level ACCF combining single level ACDF (AcA) is an ideal way to treat CSM with multiple consecutive cervical intervertebral disc herniation alongside with severe bony narrowing of the spinal canal in between. AcA with the stand-alone technics on the ACDF level and a shorter titanium plate that only covers the ACCF levels (AcAsa) may possess potential advantages than conventional AcA. We performed a retrospective study to evaluate the feasibility, safety and effectiveness of AcAsa procedure.

Methods

379 patients with CSM who had conventional AcA or AcAsa were retrospectively reviewed. Related patients factors, disease factors and treatment factors were acquired and subjected into student's t test, chi-square test and survive analyses.

Results

Preoperative and postoperative JOA Scores in AcAsa: $p<0.001$. Preoperative and postoperative VAS Scores in AcAsa: $p<0.001$. 12months improvement of JOA Score between preoperative VAS Score≥2 and <2 in AcAsa: $p=0.002$. The amount of intraoperative blood loss between AcAsa and conventional AcA: $p=0.011$. Incidence of postoperative dysphagia between AcAsa and conventional AcA: $p=0.038$.

Conclusion

AcAsa significantly improve patients' JOA Scores and reduce VAS Scores. Compared with conventional AcA, AcAsa leads to smaller amount of intraoperative blood loss and lower incidence of postoperative dysphagia. The alleviations of neurological symptoms, cervical motions and disc space heights at the ACDF levels are similar between the two types of surgeries. And patients with preoperative VAS less than 2 may benefit more from an AcAsa procedure.

Introduction

Cervical spondylotic myelopathy (CSM) is one of the most commonly occurred abnormalities on human spine[1]. It's estimated that the incidence and prevalence of CSM in the North American region are at a minimum of 41 and 605 per million respectively[2]. The main cause of CSM includes degenerative disc herniation, acute traumas and ossifications on the posterior longitudinal ligament (OPLL) or the ligamenta flava[3]. Severe CSM may cause continuous numbness, pain, muscle weakness and even paralyses, leading to a significant deterioration in patients' life quality[4].

By selectively remove the herniated discs (anterior cervical discectomy and fusion, ACDF) or the larger parts of the vertebral body (anterior cervical corpectomy decompression and fusion, ACCF) to acquire decompression on the impact nerves[5], an anterior surgical intervention is considered effective and safe management for CSM.

The combination of single level ACCF and ACDF (AcA) is usually a suitable approach for patients with multiple consecutive disc herniation alongside with severe bony narrowing of the spinal canal in between. After the decompression processes are completed, a titanium mesh and an intervertebral fusion cage will be implanted with a four level titanium plates at the anterior site to cover the entire involved spinal level.

AcA surgeries usually possess satisfying outcomes in alleviating neurological symptoms. However, despite all the advantages of anterior cervical procedures, the loss of cervical mobility postoperatively and the following consequences that some patients may feel consistent sore and discomfort at the neck are now drawing more attentions among surgeons. According to Yang's research, patients who had ACCF surgeries could loss 9.8% and 28.5% on their cervical flexion and extension abilities[6]. And raising possibilities of potential long term adjacent segmental degenerations (ASD) after surgeries is also a disturbing problem[7].

Compared to traditional ACDF, stand-alone technic used in the ACDF is one of the popular updates. By using the novel kind of self-locking intervertebral fusion cage instead of conventional ones, titanium plate implantations are no longer needed. Nambiar's reported that the use of stand-alone cage in ACDF has the same surgical outcomes and lower incidence of postoperative dysphagia compared to conventional ACDF[8].

So in light of such reports and experiences, in the recent decade, our department had made attempt to perform a series of AcA surgeries with the stand-alone technics on the ACDF level and a shorter titanium plate that only covers the ACCF levels (AcAsa). In the meantime, a series of conventional AcA were conducted as well. We collected and compared the related data of these patients and followed their status to evaluate the security, feasibility and effectiveness of AcAsa.

Materials And Methods

Patients

From 2010 to 2018, 379 patients from our department who had been diagnosed with confirmed CSM based on their signs, symptoms and radiographic evidences were included in this series. The preoperative evaluations had deemed them suitable for the AcA surgeries. This study was approved by our hospital's ethics committee. Informed consents were obtained from all the participants.

Patients' medical records, preoperative and postoperative images were retrospectively reviewed and analyzed. Follow-ups were conducted every 6 months for the first year after surgeries, then once a year thereafter. All patients were followed for at least 1 year. Cervical anterior, lateral, extension and flexion X-rays were performed at each follow-up. Patients' information including general conditions, neurological function status and X-rays characteristics were reviewed and evaluated.

Treatments

All patients received thorough assessments before surgeries, including physical examination, full series of blood tests, chest X-ray, abdominal ultrasound, electrocardiogram, and X-ray, computed tomography and magnetic resonance imaging scan of the cervical spine.

Surgery indications were as follow: (1) Confirmed CSM with spinal cord compression along with intolerable pain/numbness or neurological defects. (2) Patient's symptoms were not significantly reduced or even deteriorated after conservative treatments. (3) Patient's general conditions were considered tolerable for surgical intervention. Individualized surgical strategy was designed mainly based on patients' signs and symptoms and radiographic evaluations. Additionally, if with instability of the would-be ACDF level, patients were excluded from the AcAsa group.

Postoperatively, each patient was told to stay in bed for 24h if not having intraoperative cerebrospinal fluid (CSF) leakage and given methylprednisolone injection for 3 days. After being discharged, a 3-months cervical collar

protection was advised to them.

Statistical analysis

Attributes data are described by mean± standard deviation (range, median). Measurements data are described as counts (percentage). A series of clinical factors were analyzed and compared. Patient factors include age and gender. Disease factors include symptom duration, trauma history, OPLL, preoperative and postoperative Japanese Orthopedic Association (JOA) Scores and Visual Analogue Scale (VAS) Scores. Surgery factors include cage/mesh relative position, operative duration, blood loss, length of hospital stay, complications, cervical motions and disc space height of the ACDF levels. Bony fusion was defined as the absence of radiolucent lines across the fusion site. And the cage shift was measured by the distance change between its metal maker and the posterior edge of the vertebral body

The Student's t tests were used to compare the attributes data and the Chi-Square tests were used in measurement data. Survival curves were constructed using the Kaplan–Meier method, and the log-rank test was used to compare the survival curves. A p value (two-sided) ≤ 0.05 was considered statistically significant. All analyses were carried out using the SPSS for windows, version 22.0.0 (SPSS, IBM corp., New York, USA).

Results

A total of 379 CSM patients, including 259(68.34%) male and 120(31.66%) female, had undergone surgical intervention of AcA. No patient died at our last follow-ups. The average age was 56.25 ± 10.13 (range 22–84, 56). 71 (18.73%) patients had histories of cervical injury. And 87 (22.96%) patients were diagnosed with confirmed OPLL. The average preoperative JOA and VAS Scores were 11.04 ± 2.23 (0–14, 11) and 1.66 ± 1.49 (0–6, 2) respectively.

According to our data, 133(35.09%) patients had AcA. The rest 246(64.91%) had AcAsa. There were no statistical differences on the preoperative factors between the two groups. The corpectomy level was among C3-C7 and the discectomy level was at the nearest intervertebral space above or below. The count of the cage-above-mesh type was 223 (58.84%) and the cage-below-mesh type was 156(41.16%) (Fig. 1). The average surgery time was 135.73 ± 33.34 (75–318, 130) minutes and the average blood loss was 117.45 ± 106.06 (30-1000, 100) ml. 4(1.06%) patients had intraoperative blood transfusion. 13(3.43%) patients had CSF leakage. And 3(0.79%) patients had suffered from acute postoperative hematoma, which then been dealt with emergency second time surgeries.

All patients had experienced smooth recoveries. Compression bandages around the neck were applied to patients with CSF leakage. All the leakages stopped within the first week. 24(6.33%) patients complained about dysphagia after surgeries. No other severe complications took place after surgeries. The average hospital stay time was 7.19 ± 1.66 (2–19, 7) day. 28 (15 AcA /13 AcAsa) patients' radiographic follow-ups were lost. Detailed patients' information is listed in Table 1.

Table 1
Demographics and clinical characteristics of the patients included in the series.

Time	JOA Score	p	RIS (%)	VAS Score	p
1 day	12.57 ± 1.87	< 0.001	21.63 ± 24.35	1.03 ± 1.14	< 0.001
6 months	13.10 ± 1.71	< 0.001	30.14 ± 24.31	0.69 ± 0.86	< 0.001
12 months	13.58 ± 1.69	< 0.001	39.68 ± 24.17	0.56 ± 0.80	< 0.001

Surgical Feasibility Of AcAsa

The average JOA Scores of the AcAsa group 1 day, 6 months and 12months postoperatively were 12.57 ± 1.87 (6–16, 13), 13.10 ± 1.71 (8–16, 14) and 13.58 ± 1.69 (8–16, 14). The corresponding improvement rates of JOA Score (RIS) were 21.63%±24.35% (-66.67%-75%, 25.00%), 30.14%±24.31% (-66.67%-75%, 33.33%) and 39.68 ± 24.17 (-33.33%-83.33%, 42.86%). And the average VAS Scores 1 day, 6 months and 12months postoperatively were 1.03 ± 1.14 (0–5, 1), 0.69 ± 0.86 (0–4, 0) and 0.56 ± 0.80 (0–4, 0). At each mentioned time point, the postoperative JOA and VAS Scores were significantly higher than the preoperative ones (Table 2).

Table 2
Post-operative JOA scores in AcAsa group and statistical comparisons with pre-operative JOA score.

Factors	RIS after Surgery (%)					
	1 day	p	6 months	p	12 months	p
Gender (M/F)	21.05 ± 27.64 /20.49 ± 24.43	0.879	31.30 ± 22.99 /29.68 ± 22.99	0.615	39.18 ± 24.76 /40.86 ± 22.82	0.620
Age (≥ 56/<56)	22.08 ± 24.43 /19.65 ± 28.88	0.476	29.53 ± 23.49 /32.15 ± 22.41	0.373	39.35 ± 22.79 /40.01 ± 25.60	0.831
Symptom Duration (≤ 12months/>12months)	23.81 ± 22.93 /18.81 ± 26.11	0.112	32.91 ± 21.18 /27.96 ± 25.01	0.095	41.82 ± 23.38 /36.75 ± 25.02	0.105
Cage Location (above/below)	22.88 ± 24.87 /18.21 ± 28.85	0.175	30.25 ± 23.76 /31.58 ± 21.91	0.656	39.01 ± 24.54 /40.57 ± 23.75	0.617
Trauma (yes/no)	18.00 ± 19.36 /21.35 ± 27.68	0.498	29.27 ± 17.82 /31.07 ± 23.70	0.672	40.30 ± 19.95 /39.58 ± 24.82	0.873
OPLL (yes/no)	14.86 ± 21.54 /21.82 ± 27.32	0.164	29.09 ± 22.38 /31.09 ± 23.08	0.644	36.99 ± 24.83 /40.09 ± 24.10	0.494
Preoperative JOA Score (≥ 12/<12)	22.60 ± 27.69 /19.57 ± 24.11	0.359	29.73 ± 24.49 /31.82 ± 21.49	0.477	40.69 ± 25.91 /38.74 ± 22.50	0.529
Preoperative VAS Score (≥ 2/<2)	18.17 ± 24.87 /24.85 ± 23.63	0.032	26.64 ± 23.06 /34.55 ± 22.29	0.007	34.71 ± 24.29 /44.11 ± 23.27	0.002

We analyzed the postoperative RIS between several sub-groups from the AcAsa group to determine whether any certain kinds of patients may benefit more from AcAsa. The sub-groups divided by gender, age, symptom duration, cage-mesh relative position, trauma history, OPLL and preoperative JOA Score showed no statistical differences in the postoperative RIS at the time points of 1 day, 6 months, and 12 months. However, at each time point, patients with preoperative VAS Score < 2 had more favorable outcomes then patients whose preoperative VAS Score ≥ 2 (p = 0.032/0.007/0.002) (Table 3).

Table 3
Post-operative improvement rates of JOA score in different sub-groups of the AcAsa group.

Factors	N(AcAsa / AcA)	p
Operative Duration	-	0.400
Blood Loss	-	0.011
Blood Transfusion	2/2	0.530
CSF Leakage	6/7	0.086
Acute Hematoma & Reoperation	2/1	0.949
Length of Hospital Stay	-	0.782
Dysphagia	11/13	0.038
12months Postoperative Cage Shift ≥ 3 mm	4/6	0.092
12months Postoperative ASD	11/7	0.617

Surgical Safety Of AcAsa

To compare the surgical safety outcomes between AcAsa and conventional AcA, we analyzed the factors of operative duration, blood loss, intraoperative blood transfusion and the length of hospital stay. We also compared the incidence of acute postoperative complications like CSF leakage, acute hematoma and postoperative dysphagia. Long-term complications, including the incidence of cage shift, cervical instable, delayed fusion at the ACDF level and ASD at 12 months postoperatively were compared as well. Our results showed that patients who had AcAsa had a smaller amount of blood loss than AcA (P = 0.011). Moreover, the incidence of postoperative dysphagia is significantly lower in the AcAsa group (p = 0.038). No postoperative cervical instable or delayed fusion on the ACDF level was found on all patients at our final follow-ups. On our one year follow-ups, 6 (5.08%) patients in the AcA group and 4 (1.72%) patients in the AcAsa group had severe cage shift (≥ 3 mm). 7 (5.93%) patients in the AcA group and 11 (4.72%) patients in the AcAsa group had developed confirmed ASD before the last followed-ups. No statistical differences were found on the incidence of these complications (Table 4).

Table 4

Comparisons of surgical safety factors and complications between AcAsa and AcA group.

Factors (AcAsa / AcA)	Pre-surgery	p	Time after Surgery					
			1 day	p	6 months	p	12 months	p
RIS (%)	-	-	21.63 ± 24.35 /18.10 ± 22.78	0.170	30.14 ± 24.31 /29.36 ± 18.46	0.747	39.68 ± 24.17 /38.32 ± 21.14	0.585
VAS Score Reduction	-	-	0.71 ± 0.82 /0.53 ± 0.83	0.038	0.87 ± 0.98 /1.02 ± 0.95	0.143	1.00 ± 1.09 /1.15 ± 1.03	0.193
Cervical Motion (°)	8.36 ± 4.18 /9.26 ± 4.53	0.064	-	-	3.97 ± 3.06 /3.57 ± 2.52	0.222	2.19 ± 2.23 /2.25 ± 1.56	0.784
Disc Space Height (mm)	11.74 ± 2.26 /11.59 ± 2.29	0.531	11.37 ± 2.29 /11.33 ± 2.24	0.860	11.44 ± 2.30 /11.51 ± 2.42	0.802	11.64 ± 2.26 /11.43 ± 2.24	0.407
Symptom Recurrence	-	-	-	-	10/9	0.324	18/15	0.251

Surgical Effectiveness Of AcAsa

Finally, we compared the surgical effectiveness and outcomes between AcAsa and AcA. No differences were shown on the RIS at 1 day, 6months and 12months postoperative. The comparing in between VAS Scores showed that the improvement of VAS Score was significantly higher in the AcAsa group 1 day after surgeries, but revealed no differences at 6months and 12mongths follow-ups. Patients' disc space height and cervical motion of the ACDF levels at the 6months and 12months postoperative showed no differences between the two groups. In the end, during our follow-ups, 10 (4.07%) patients in the AcAsa group and 9 (6.77%) in the AcA group complained about the recurrence of symptom within the first 6 months, and the number of symptom recurrence raised to 18 (7.32%) and 15 (11.28%) respectively at 12 months follow-up. Chi-square test and survival curves for the symptom recurrence free survival (SRFS) rate both showed no statistical differences in the two groups (Table 5 & Fig. 2).

Factors (AcAsa / AcA)	Pre-surgery	p	Time after Surgery					
			1 day	p	6 months	p	12 months	p
RIS (%)	-	-	21.63±24.35 /18.10±22.78	0.170	30.14±24.31 /29.36±18.46	0.747	39.68±24.17 /38.32±21.14	0.585
VAS Score Reduction	-	-	0.71±0.82 /0.53±0.83	**0.038**	0.87±0.98 /1.02±0.95	0.143	1.00±1.09 /1.15±1.03	0.193
Cervical Motion (°)	8.36±4.18 /9.26±4.53	0.064	-	-	3.97±3.06 /3.57±2.52	0.222	2.19±2.23 /2.25±1.56	0.784
Disc Space Height (mm)	11.74±2.26 /11.59±2.29	0.531	11.37±2.29 /11.33±2.24	0.860	11.44±2.30 /11.51±2.42	0.802	11.64±2.26 /11.43±2.24	0.407
Symptom Recurrence	-	-	-	-	10/9	0.324	18/15	0.251

Table 5 Surgical outcomes between AcAsa and AcA group.

Discussion

Stand-alone ACDF has been widely explored in recent years[9]. It is reported that the stand-alone technic presents many advantages compared with conventional ACDF. Lu's research showed that in treating two level CSM, ACDF with stand-alone cage is associated with greater postoperative disc height and reduced chances of cervical lordosis[10]. Kapetanakis also proved that single level ACDF using stand-alone cage could significantly improve patients' life qualities[11].

Despite that many evaluations of ACDF with stand-alone cages have been conducted, there are few researches focus on the use of stand-alone cages in complex anterior cervical surgeries combines both ACDF and ACCF procedures. Due to that fact, we made hypothesis that AcAsa procedure may benefit the surgical outcomes then conventional AcA.

The JOA Score for CSM, an inquiry system first published by Fukui in 2008[12], had been widely used as an evaluating standard. So here we applied it to most of our outcomes. All patients in the AcAsa group had significant increase in the JOA scores after surgery. We compare different patient sub-groups from the AcAsa group in order to precisely evaluate which types of patients are more fitful of going through AcAsa. From our results, we found no difference in the alleviation of neurological symptoms in patients with different gender, age, symptom duration and preoperative JOA Scores. Whether the patient has trauma history or OPLL diagnosis does no affect surgery outcomes as well. Additionally, the outcomes in the two different relative positions between ACCF and ACDF levels revealed no differences as well. So these factors are not limitations for us in making surgical plans.

The VAS Score is a commonly used scoring system for the patients to describe their experience of pain[13]. However other than cervical spondylotic radiculopathy, CSM are more likely to cause numbness and weakness than pain. Thus, the average preoperative VAS Score in our series was only 1.66 ± 1.49. Still, our analyses demonstrated that the VAS Scores in the AcAsa group had significantly decreased after surgeries. Also it is interesting that patients who have preoperative VAS Score less than 2 may have better RIS after AcAsa. To our understanding, high preoperative VAS Score may suggest potential compressions on the nerve roots. So according to this outcome, AcAsa may not provide the most efficient decompression effect on the nerve roots.

Compared with conventional AcA, our series of AcAsa did not lead to the increase of postoperative complications. The fact may indicate that the protection of the titanium plate in front of the ADCF level in AcA does not help with the prevention of cage shifting or subsidence, so as well with further cervical degenerations.

The amount of intraoperative blood loss and the incidence of postoperative dysphagia of AcAsa were lower compared with conventional AcA as it causes smaller injuries to the bones and esophagus during operations. Furthermore, although the incidence of CSF leakage does not show difference, the actual rate of CSF leakage in the AcA group is more than twice as much as in AcAsa group. These facts together may suggest that AcAsa possesses lower surgical risk than conventional AcA.

Finally, in evaluation of surgical outcomes, both group shared similar RIS. The decreasing of VAS Score was greater in the AcAsa group on the first day after surgery although tend to equality in 6months and 12months. We deemed that it may affected by patients' subjective feelings and many other factors such as the effects of methylprednisolone. Due to the fusing process of the bone grafts, the cervical motions in the ACDF levels both showed a similar reduction trend through time. Both groups had patients complained about symptom recurrence, which maybe because of ASD or potential compressions remained on the surgery sites.

In conclusion, we retrospectively reviewed a total of 379 patients with CSM who had conventional AcA or AcAsa. AcAsa significantly improve patients' JOA Scores ($p < 0.001$) and reduce VAS Scores ($p < 0.001$). Compared with conventional AcA, AcAsa has smaller amount of intraoperative blood loss ($p = 0.011$) and lower incidence of postoperative dysphagia ($p = 0.038$). The alleviations of neurological symptoms, cervical motions and disc space heights at the ACDF levels are similar between the two types of surgeries. And patients with preoperative VAS less than 2 may benefit more from AcAsa ($p = 0.002$).

Abbreviations

CSM
cervical spondylotic myelopathy
OPLL
ossifications on the posterior longitudinal ligament
ACDF
anterior cervical discectomy and fusion
ACCF
anterior cervical corpectomy decompression and fusion
AcA
single level ACCF combining single level ACDF
ASD
adjacent segmental degenerations
AcAsa
AcA surgeries with the stand-alone technics on the ACDF level and a shorter titanium plate that only covers the ACCF levels
CSF
cerebrospinal fluid
JOA
Japanese Orthopedic Association
VAS

Visual Analogue Scale

Declarations

Ethics approval and consent to participate

The research involved the use of hospital documentaries of 79 patients. This study was approved by our hospital's ethics committee and had been performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. Informed consents were obtained from all the participants.

Consent for publication

Informed consent for publication was obtained from all individual participants for whom identifying information is included in this article (See in supplementary information files).

Availability of data and material

All data generated or analysed during this study are included in this published article (and its supplementary information files).

Competing interests

None.

Funding

None.

Authors' contributions

X. C. and S. Z. designed the study. Z. Z., J. C. and W. S. collected and analyzed the data. Z. Z., X.C. and L.J. wrote the manuscript. All authors discussed the results and critically revised the manuscript.

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Figures

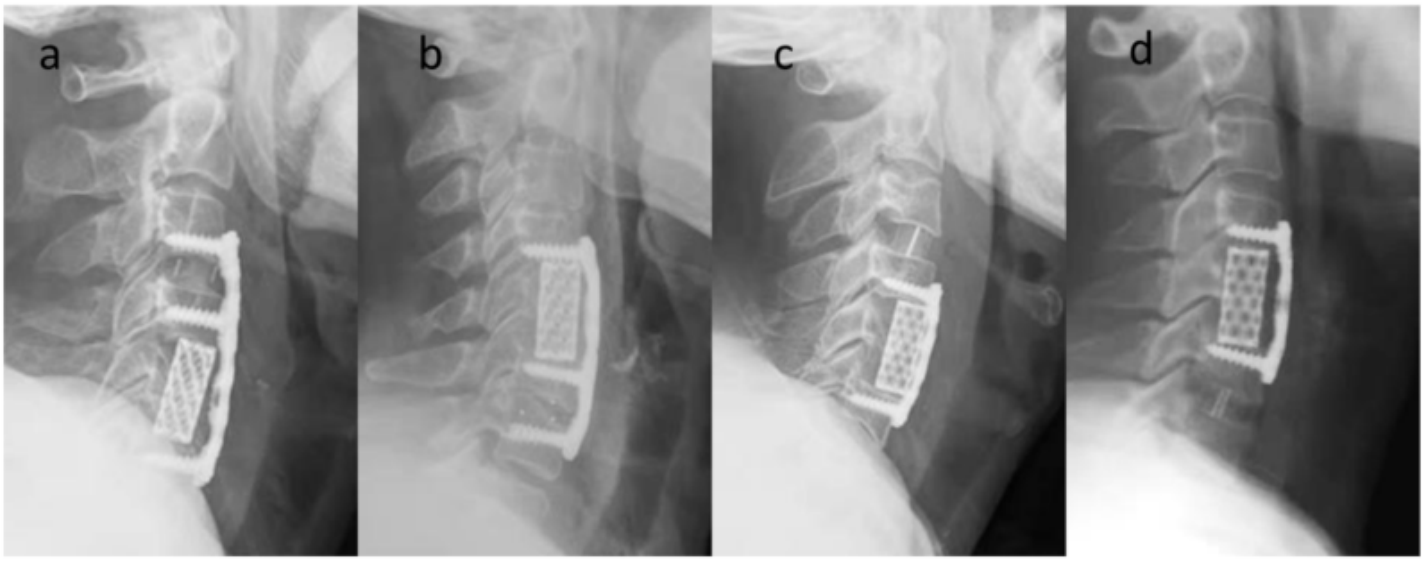

Figure 1

Postoperative X-rays, a: AcA (cage-above-mesh type); b: AcA (cage-below-mesh type); c: AcAsa (cage-above-mesh type); d: AcAsa (cage-below-mesh type).

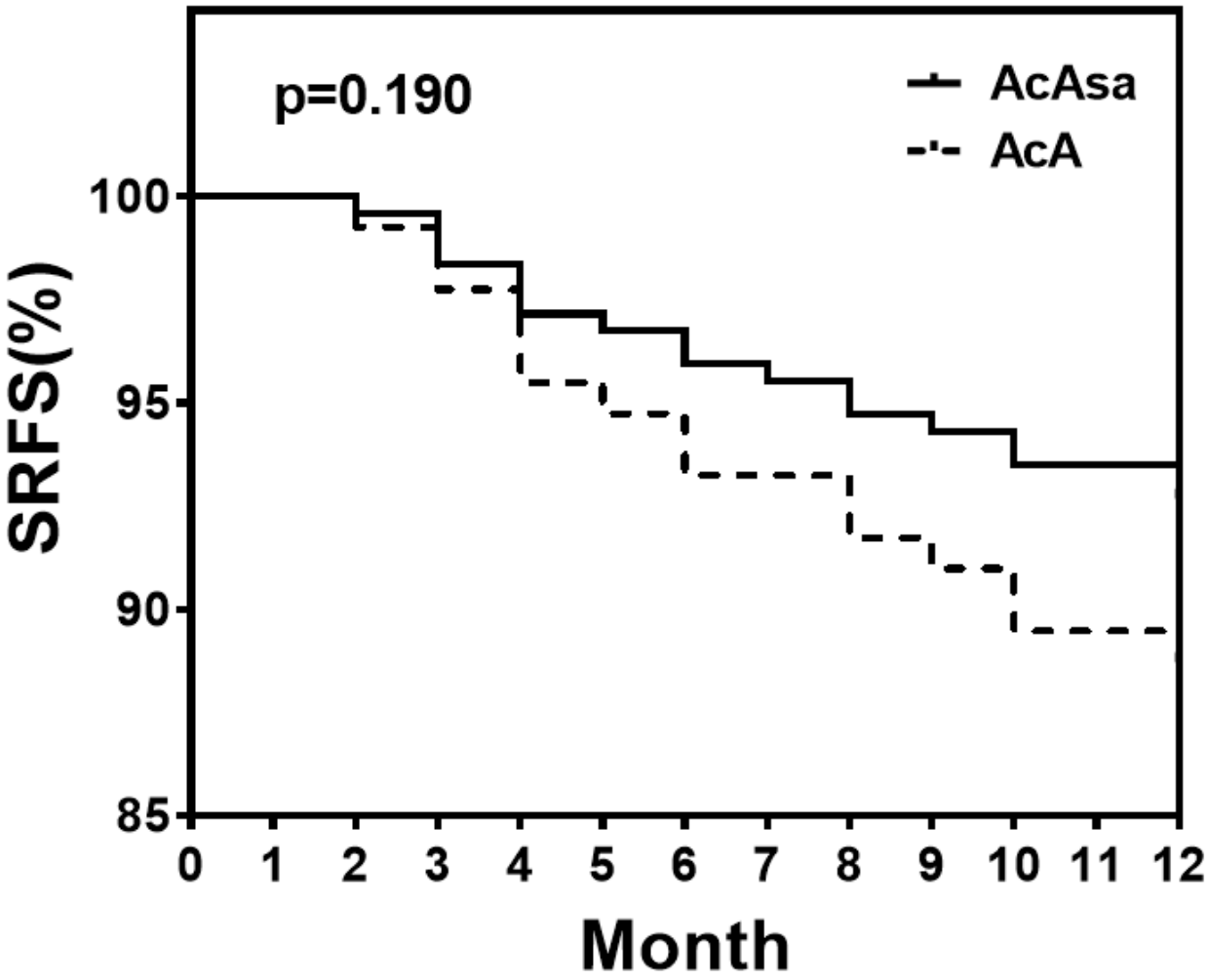

Figure 2

Kaplan–Meier curve of SRFS in AcAsa and AcA group, p=0.190.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- PatientsDetail.xlsx