Over-correction of curvature causes the non-surgical curvature loss in one- and two-level anterior cervical discectomy and fusion

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To the Editor: Cervical disc degenerative disease (CDDD) is a common clinical spinal disease, which has a great impact on the quality of life of middle-aged and elderly patients.[1,2] Although it is challenged by advanced surgical techniques, anterior cervical discectomy and fusion (ACDF) is still the best choice for most patients with CDDD.[3,4] In most cases, the focus of ACDF surgery is "decompression." However, for patients with pre-operatively poor curvature, in addition to the decompression of the nerve to relieve symptoms, it is also vital to improve the cervical curvature.[5]

Theoretically, ACDF will only change the curvature of the surgical part, while the curvature of non-surgical segments should not be affected, which means that the "correction degree of the C2-7 Cobb angle" should be theoretically equal to the "correction degree of the functional segment unit (FSU)." However, we did observe that the curvature of non-surgical segments of most patients was slightly increased or unchanged compared with that before the operation, whose clinical results were often relatively ideal, while it was also noticed that some patients suffered from a loss in the curvature of non-surgical segments. We defined this phenomenon as "non-surgical curvature loss (NSCL)," as shown in Figure 1A and 1B.

This study has institutional review board approval. A total of 122 patients who suffered from a poor cervical curvature, and were treated on a one- or continuous two-level ACDF between C3-7 with Zero-P spacer from October 2012 to June 2016 were consecutively included in the study. The inclusion criteria for the present study were clearly defined, as follows: (1) the patient's symptoms and radiological results were consistent with the typical diagnosis of CDDD; (2) the patient's pre-operative C2-7 Cobb angle was $<10°$; (3) the patients were successfully followed up at every time point; (4) no other cervical surgery was performed during the follow-up. One senior spinal surgeon performed all the surgical procedures using the standard ACDF technique with proper Zero-P spacers (Synthes GmbH, Oberdorf, Switzerland).

Lateral cervical radiograph examination was performed at every follow-up time point. NSCL was calculated as follows: NSCL = (post-operative Cobb angle of non-surgical segments) − (pre-operative Cobb angle of non-surgical segments). Simultaneously, the following items would be finished at every follow-up time point: (1) visual analog score (VAS) for arm (VAS-arm) and neck (VAS-neck), respectively; (2) Japanese Orthopedic Association (JOA) scale; (3) Neck disability index (NDI). The diagnosis of adjacent segment degeneration (ASD) is mainly determined by relevant clinical manifestations. Intervertebral fusion is judged by computerized tomography. Implant dislocation/subsidence is defined as anteroposterior translocation of an implant >3 mm or a loss of FSU height >3 mm compared with the outcome at the initial post-operative follow-up.

The analysis was conducted using SPSS version 19.0 (SPSS, Chicago, IL, USA). The level of significance was set at $P < 0.05$. Chi-squared analysis and unpaired t-test were used, respectively, for categorical and continuous data between groups, while paired t-test was used to compare the data of the one group from different time points. Pearson correlation tests were used to analyze the correlation between data of different groups. Univariate and multivariate logistic regression analyses were used to screen and assess the risk factors for NSCL, with the verification by characteristic receiver operation curves (ROC). A statistical power with a significant level (alpha) of 0.05 was calculated using the G-Power software (version 3.1.9.4) when there was a statistical difference.[6] All values were expressed in mean ± standard deviation or percentage.

A total of 122 patients (59 males and 63 females) met the inclusion criteria, and agreed to accept one-level ($n = 72$)

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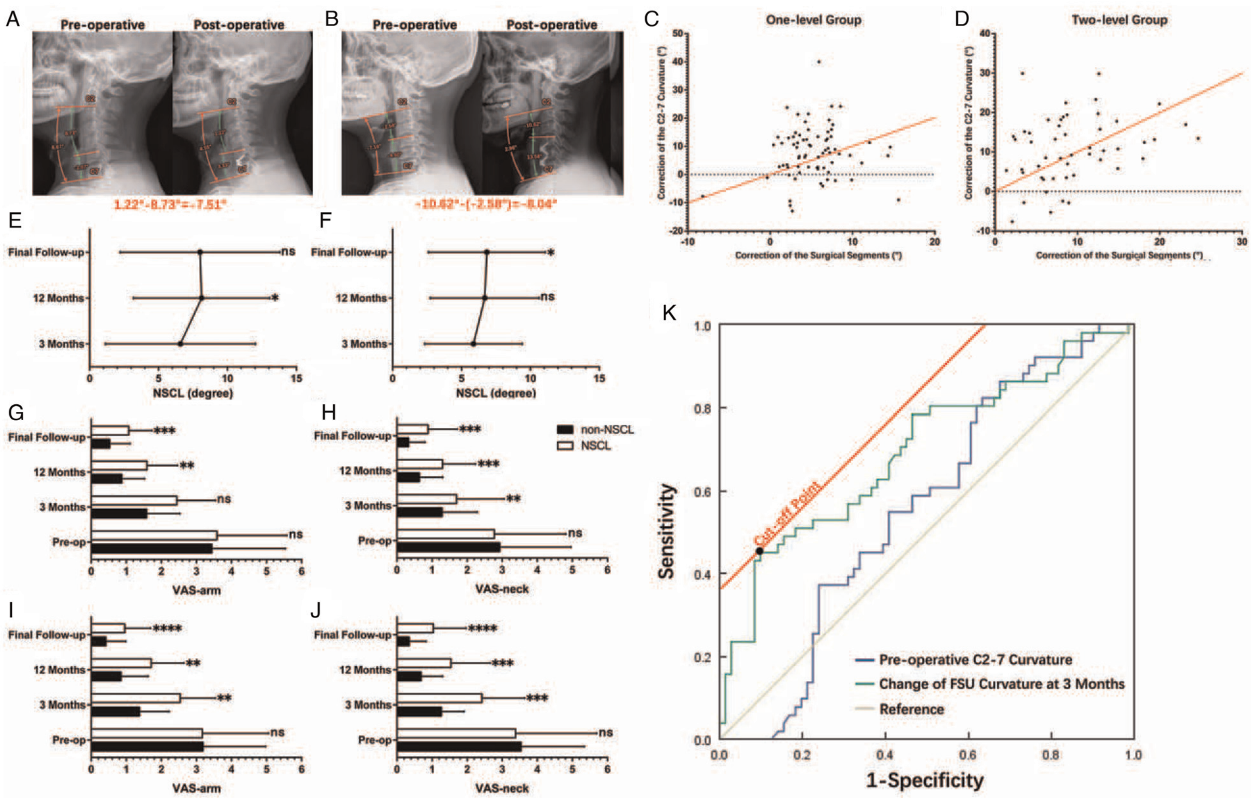

Figure 1: Typical case of patients with NSCL of one-level and two-level groups (A and B); correlation analysis between correction degree of surgical segments and C2-7 Cobb angle In one-level and two-level groups (C and D); NSCL change during follow-up from one-level and two-level groups (E and F); VAS-arm and VAS-neck comparison between NSCL and non-NSCL in the one-level group (G and H); VAS-arm and VAS-neck comparison between NSCL and non-NSCL in two-level group (I and J); ROC curve and cut-off point (K). NSCL: Non-surgical curvature loss; ROC: Receiver operation curves; VAS-arm: Visual analog score (VAS) for arm; VAS-neck: Visual analog score (VAS) for arm (VAS-arm) and neck.

or two-level ($n = 50$) ACDF. The mean age was 51.58 ± 12.69 years, and the average follow-up period was 22.87 ± 3.15 months. Thirty-one patients suffered from radiculopathy, 34 suffered from myelopathy, and 47 suffered from both of them.

The pre-operative C2-7 Cobb angle of one-level ACDF was $4.05° \pm 5.18°$, and at the final follow-up, it was $10.91° \pm 8.82°$ ($P < 0.01$). The pre-operative C2-7 Cobb angle of two-level ACDF was $2.46° \pm 7.27°$, and at the final follow-up, it was $13.15° \pm 7.98°$ ($P < 0.01$). Furthermore, the pre-operative Cobb angle of the FSU in one-level ACDF was $-2.04° \pm 6.28°$, and at the final follow-up, it was $3.07° \pm 5.03°$ ($P < 0.01$). The pre-operative Cobb angle of the FSU in two-level ACDF was $-1.02° \pm 7.14°$, and it was $8.66° \pm 6.99°$ at the last follow-up ($P < 0.01$). It can be noticed that the cervical curvature in patients with both one- and two-level ACDF significantly improved after surgery. In addition, no further loss of cervical curvature occurred after the patient's improvement, indicating that the cervical curvature was well-maintained.

As shown in Figure 1C and 1D, the results at postoperative 3 months were analyzed, and it was found that the correlations in both one-level ($\rho = 0.10$, $P = 0.41$) and two-level ($\rho = 0.29$, $P = 0.04$) ACDF were relatively poor, indicating there is the mismatching. The data point on the lower right of the diagonal line can be observed, that is, there are not a few patients with NSCL, with an incidence of 37.5% (27/72) in patients with one-level ACDF and 48.0% (24/50) in patients with two-level ACDF while there was no significant difference ($P = 0.25$). As shown in Figure 1E and 1F, the degree of NSCL of both groups with one- or two-level ACDF did not differ a lot among the follow-up period and no cases were found to switch from NSCL group to non-NSCL group.

As shown in Figure 1G–J, the VAS-arm and VAS-neck of patients with NSCL were significantly higher than those of non-NSCL patients, regardless of one- or two-levels, and this difference lasted until the final follow-up. In the one-level group, the recovery rate of VAS-neck ($70.0\% \pm 40.6\%$ *vs.* $47.0\% \pm 48.4\%$, $P = 0.04$) was higher in patients without NSCL. In the two-level group, the recovery rates of VAS-arm ($81.7\% \pm 28.5\%$ *vs.* $52.1\% \pm 43.9\%$, $P < 0.01$) and VAS-neck ($81.7\% \pm 31.9\%$ *vs.* $52.2\% \pm 47.1\%$, $P = 0.01$) were both higher in patients without NSCL. The other indicators including NDI and JOA showed no differences between groups. This result suggests that the presence of NSCL may have a negative impact on the recovery of radiculopathy.

For short-term complications, we found that at the 3 months post-operatively, there were no differences of incidences of dysphagia between patients with NSCL and without NSCL (one-level, 2.2% *vs.* 3.7%, $P = 0.71$; two-level, 7.7% *vs.* 4.2%, $P = 0.60$), infection (one-level, 0 *vs.*

0; two-level, 0 *vs.* 0), dysphonia (one-level, 0 *vs.* 0 two-level, 0. *vs.* 4.2%, $P = 0.29$). For long-term complications, we observed at the final follow-up that the presence of NSCL did not affect the incidence of related complications, including ASD (one-level, 4.4% vs. 3.7%, $P = 0.93$; two-level, 3.8% *vs.* 4.2%, $P = 0.95$), non-fusion (one-level, 2.2% *vs.* 0, $P = 0.44$; two-level, 0 *vs.* 4.2%, $P = 0.29$), implant dislocation/subsidence (one-level, 0 *vs.* 0; two-level, 0 *vs.* 0).

We firstly conducted a univariate factor analysis for NSCL and four potential risk factors including "operation time," "pre-operative C2-7 curvature," "pre-operative FSU curvature," and "change of FSU curvature at 3 months" were confirmed by using "$P < 0.20$" as the standard. Put the above independent variables into the multivariate Logistic regression analyses model, while "pre-operative C2-7 curvature" and "change of FSU curvature at 3 months" have a significant correlation with the occurrence of NSCL. Further, we build the ROC curves for the efficiency of the above factors in predicting the occurrence of NSCL, respectively, as shown in Figure 1K, and calculate the area under the curve (AUC) to verify the predictive values. "Change of FSU curvature at 3 months" has a certain degree of predictive value for the occurrence of NSCL ($AUC = 0.70$, $P < 0.01$), while the cut-off point was 8.62° (sensitivity = 0.45, 1-specificity = 0.10): if the correction of FSU is >8.62°, the risk of NSCL is significantly increased post-operatively. The treatment of CDDD focuses on relieving neurological symptoms and reconstructing the spinal structure.[7] The ways to relieve neurological symptoms are similar, while the reconstruction of the spinal structure differs from person to person, and there are great differences among patients, which require physicians to treat each patient's unique "personality" separately.

The poor curvature of the cervical spine is a common clinical condition, and for these patients, the "reconstruction of the spinal structure" is really important.[8] The correction of the cervical curvature is mainly achieved by reconstructive surgery. With the incidence of 37.5% in one-level ACDF and 48.0% in two-level ACDF, NSCL is not a rare phenomenon.

As mentioned, we compared a lot of data from the two groups of patients. The result shows that operation time, pre-operative C2-7 curvature, pre-operative FSU curvature, and change of FSU curvature at 3 months may be related to the occurrence of NSCL. A smaller "pre-operative FSU curvature" leads to a higher risk of NSCL, which is easier to understand because the surgeon is more likely to correct the curvature of the FSU of this group of patients. And "pre-operative C2-7 curvature" shows the baffling opposite result, which I personally believe is a distraction for false positives. In addition, although not included in this study due to the lack of intra-operative imaging data, we believe that the placement of the operative position may also influence the occurrence of NSCL: pre-operative fixation of the cervical spine in the hyperextension position should not be overdone to prevent overcorrection of the surgical levels. This means that, presently, "change of FSU curvature at 3 months" is the only factor with statistical significance that can reasonably explain the occurrence of NSCL.

For patients with poor cervical curvature before surgery, ACDF is a very effective surgical method. However, during ACDF surgery, the over-correction in the curvature of the FSU may cause the occurrence of NSCL, which may affect the recovery of the symptoms of upper limb pain and neck pain.

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References

1. Peng B, DePalma MJ. Cervical disc degeneration and neck pain. J Pain Res 2018;11:2853–2857. doi: 10.2147/JPR.S180018.
2. Yang X, Karis DSA, Vleggeert-Lankamp CLA. Association between Modic changes, disc degeneration, and neck pain in the cervical spine: a systematic review of literature. Spine J 2020;20:754–764. doi: 10.1016/j.spinee.2019.11.002.
3. Byvaltsev VA, Stepanov IA, Riew DK. Mid-term to long-term outcomes after total cervical disk arthroplasty compared with anterior diskectomy and fusion: a systematic review and meta-analysis of randomized controlled trials. Clin Spine Surg 2020;33:192–200. doi: 10.1097/BSD.0000000000000929.
4. Guo H, Sheng J, Sheng WB, Liang WD, Wang J, Xun CH. An eight-year follow-up study on the treatment of single-level cervical spondylosis through intervertebral disc replacement and anterior cervical decompression and fusion. Orthop Surg 2020;12:717–726. doi: 10.1111/os.12634.
5. Yuan H, Zhang X, Zhang LM, Yan YQ, Liu YK, Lewandrowski KU. Comparative study of curative effect of spinal endoscopic surgery and anterior cervical decompression for cervical spondylotic myelopathy. J Spine Surg 2020;6:S186–S196. doi: 10.21037/jss.2019.11.15.
6. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 2007;39:175–191. doi: 10.3758/bf03193146.
7. Sawada M, Nakae T, Munemitsu T, Hojo M. Functional connectivity analysis and prediction of pain relief in association with spinal decompression surgery. World Neurosurg 2020;139:e316–e324. doi: 10.1016/j.wneu.2020.03.200.
8. Du W, Wang L, Shen Y, Zhang Y, Ding W, Ren L. Long-term impacts of different posterior operations on curvature, neurological recovery and axial symptoms for multilevel cervical degenerative myelopathy. Eur Spine J 2013;22:1594–1602. doi: 10.1007/s00586-013-2741-5.

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