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Original Article

Comparison of postoperative recovery and efficacy between percutaneous coblation nucleoplasty and anterior cervical discectomy and fusion for cervical disc herniation

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Abstract: We aim to assess the postoperative recovery and efficacy of percutaneous coblation nucleoplasty (PCN) and anterior cervical discectomy and fusion (ACDF) for the treatment of cervical disc herniation. A retrospective study was conducted. Fifty-two patients in two hospitals who underwent PCN or ACDF were divided into two groups: PCN group (group D, n = 24) and ACDF group (group S, n = 28). The degree of disc herniation, postoperative hospital stay, changes of Numerical Rating Score (NRS) scores and Japanese Orthopaedic Association (JOA) scores, hospitalization expense and operation time were observed and analyzed at the point of before surgery and 1 day, 30 days and 90 days after surgery. There is no significant difference between the two groups about the cervical disc herniation degree, average NRS scores and average JOA scores. Group D has less postoperative hospital stay, hospitalization expense and operation time ($P < 0.05$). Significant changes of NRS scores and JOA scores over time were seen ($P < 0.0001$). The male patients have higher average NRS scores than female patients on the 30th day after PCN. In group S, the male and female patients have similar average NRS scores 1 day after surgery, but on the 30th and 90th days after surgery, the male patients have higher average NRS scores than the female patients. Thus, both PCN and ACDF can treat cervical disc herniation effectively, but PCN can provide milder physical injury and earlier recovery than ACDF.

Keywords: Cervical disc herniation, the percutaneous coblation nucleoplasty, anterior cervical discectomy and fusion

Introduction

Cervical disc herniation (CDH) is a common disease, mainly due to acute or repeated minor damage to the cervical disc, causing a series of symptoms, such as upper limb pain and numbness. CDH is traditionally treated by anterior cervical discectomy and fusion (ACDF) [1, 2].

Since 1950s, anterior cervical discectomy and fusion has been widely used since it causes slight injury trauma with high safety, and can effectively relieve pain, improve neurological function and restore the physiological curvature of the cervical spine. Many surgeons have also recommended the addition of anterior plate to increase the stability of the cervical spine and maintain the intervertebral height, expecting to obtain a better effect [3, 4], which indeed leads to a higher fusion rate and a lower incidence of failure.

In 2000s, minimally invasive treatment of CDH, such as percutaneous coblation nucleoplasty (PCN) is rapidly developed because of the advantages of minimal injury and no damage to spinal stability [5, 6]. But the comparison of postoperative recovery and efficacy between the two therapies has not been thoroughly reported. Our study retrospectively analyzed 52 cases managed by the PCN and ACDF in two hospitals, and compared the postoperative recovery (e.g. postoperative hospital stay), pos-

toperative efficacy (e.g. the changes of NRS scores and JOA scores), and other variable quantity, such as hospitalization expense and operation time.

Materials and methods

This study was approved by the Ethics Committee of China-Japan Friendship Hospital and the Ethics Committee of Peking University Third Hospital. Written consent was obtained from patients.

Patients

Seventy cases with cervical disc herniation in China-Japan Friendship Hospital and Peking University Third Hospital who underwent single segmental anterior cervical discectomy and fusion or single segmental percutaneous coblation nucleoplasty between January 2014 and July 2015, were retrospectively collected. According to the following inclusion and exclusion criteria, 52 patients, aged 48 to 72 years, height 153~183 cm, weight 52~92 kg, were enrolled and analyzed, including 26 males and 26 females. The mean of disease duration was 2.8 years. 17 patients had C4-5 segment disease, 22 patients C5-6 segments disease and 13 patients C6-7 segments disease.

Inclusion criteria were 1) that conservative treatment of six months was ineffective; 2) mainly radicular symptoms, manifested as upper extremity pain, numbness; and 3) that preoperative MRI examination showed a corresponding segments of the cervical disc nerve root compression.

Exclusion criteria were 1) serious spinal cord compression and degeneration; 2) spinal stenosis, calcification of the posterior longitudinal ligament, spondylolisthesis; 3) accompanied by blood coagulation system disorders, cardiovascular disease, cancer, mental illness, etc.

Patients were divided into two groups in accordance with the operation mode: percutaneous coblation nucleoplasty (group D) and anterior cervical discectomy and fusion group (S). Among them, 24 patients were in group D, while 28 in group S.

Surgical procedure

All patients were supine with shoulder underlying soft pillow and the neck extension stretch as far as possible.

Under local anesthesia, the C-arm X-ray was used to locate the lesions intervertebral space of the patients in group D, and the puncture point was marked. The puncture site was placed between the carotid sheath and the trachea, and the left hand of the surgeon pushed the trachea and the carotid artery to either side. The puncture needle was inserted into the middle of the lesion disc. Positive lateral fluoroscopy were used to determine whether the needle were located between the central of disk. After pulling out the needle core, the cervical dedicated gasification heads was rotated along the needle sleeve. After the safety test, sustaining coblation nucleoplasty was performed for 15 seconds, with uniform rotation of 360 degrees. After the completion of the ablation, the tip performed coagulation for 15 seconds. The needle was then retreated to the anterior disc 1/3. After security test, the ablation and coagulation was performed again. Postoperative cervical collar was immobilized for 3 days.

Group S received general anesthesia, and then anterior oblique incision or transverse incision. C-arm X-ray machine were positioning vertebral position to expose the vertebra and adjacent segments. After the complete removal of the disc and part of posterior longitudinal ligament, the appropriate size Titanium mesh filled with autologous bone fragments was put into reduced pressure vessel, and the suitable size anterior cervical titanium plate was placed on the mesh, and then screwed screws. When the perspective of the location was satisfied, layer-by-layer wound closure was done. Postoperative cervical collar was fixed for two months.

Outcome measures

(1) Degree of disc herniation: Based on the methods proposed by Bonneville [7], in the MRI image, the cross-sectional area of the spinal center was divided into three equal portions, and then subdivided into four levels according to the location of the lesion reached. Level 1 represents normal spinal disc, level 2 indicates that the protrusion is located in the region of the anterior 1/3 of the spinal canal, level 3 indicates that the protrusion across the region of the anterior spinal canal 1/3, but not the posterior 1/3, and level 4, the most serious, indicates that the protrusion was more than the region of 2/3.

Table 1. Demographical information

	Group D	Group S
Size (n)	24	28
Sex (m/f)	12/12	14/14
Age (year)	59.2±5.5	60.2±6.7
Height (cm)	168.3±9.4	168.4±9.4
Weight (kg)	63.6±8.1	63.5±9.4
Degree of CDH (2/3)	21/3	23/5

Group D: percutaneous coblation nucleoplasty group; Group S: anterior cervical discectomy and fusion group.

(2) Postoperative hospital stay (in days): The days from the commencement of operation (first day) to discharge from the hospital.

(3) Numerical rating score (NRS): NRS is a patient self-assessment indicator of the degree of pain in which 0 means painless, 1-3 mild pain, 4-6 moderate pain, and 7-10 severe pain. NRS scores were recorded before and after surgery, and were followed up 30 days and 90 days after surgery.

(4) JOA score: based on neurological assessment, the JOA score (Japanese Orthopedic Association) before and after surgery for cervical disc was recorded [8].

(5) Hospitalization expense: Total expense of the patient from admission to discharge from the hospital.

(6) Operation time: from the beginning to the skin incision sewn completion time and is calculated in minutes.

(7) Complications: perioperative record airway obstruction, cerebrospinal fluid leakage, spinal cord injury, laryngeal nerve, recurrent laryngeal nerve injury and other complications and reoperation occurred.

Statistical analysis

Quantitative data are presented as mean ± SD. Student *t* test was used for the continuous variables. Statistical analysis of categorical variables were conducted with Chi-square test or Fisher's exact test where applicable. Regression analysis was used to evaluate the impacts of different factors on duration of postoperative hospital stay and costs. Significance of differences between the two groups (D and S) in NRS, JOA scores was analyzed using a three-way analysis of variance (ANOVA) with repeated measures and Bonferroni post-hoc tests. A *p*-value <0.05 was considered statistically significant. All computations were performed using statistical software R.

Results

Demographical information

Demographical information was shown in **Table 1**. The sex ratio, age, weight, height and degree of cervical disc hernitation were all not significantly different between the two groups.

PCN resulted in shorter postoperative hospital stay

The average length of postoperative hospital stay (in days) for patients in Group D was 2.08±0.78 days, while that for patients in Group S was 3.96±1.17 days (**Figure 1A**). A regression analysis showed that the difference in postoperative hospital stay between the two treatment groups was significant with a *p*-value <0.0001. Age and sex did not have significantly impact on the length of postoperative hospital stays.

PCN reduced hospitalization expense

The average hospitalization expense (in 10,000 RMB Yuan) for patients in Group D and Group S was 2.91±0.27, and 5.73±0.71, respectively (**Figure 1B**). A regression analysis showed that the average hospitalization expense for patients in the two treatment groups was significantly different with a *p*-value <0.0001. The hospitalization expense was not significantly different between male and female patients, and age did not have significant impact on hospitalization expense as well. (Note: 1 U.S. dollar = 6.52 RMB Yuan).

PCN required less operation time

The average operation time (in minutes) of Group D and Group S was 31.58±5.25, and 63.46±14.60 minutes, respectively (**Figure 1C**). A regression analysis showed that the average operation time for the two treatment groups was significantly different with a *p*-value <0.0001. The average operation times for male and female patients was not significantly different, and age did not have a significant impact.

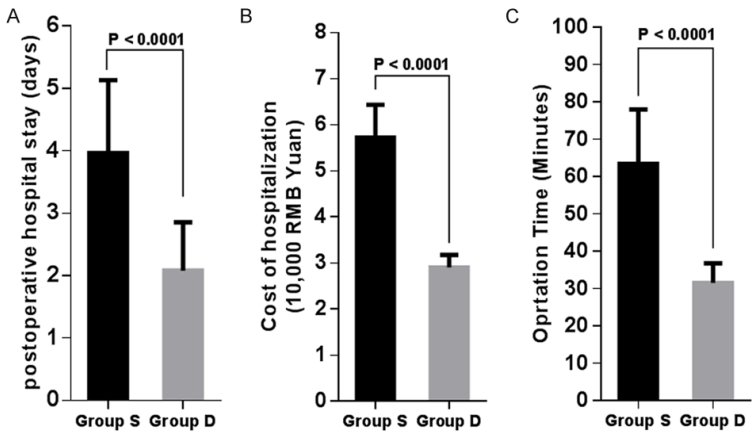

Figure 1. Postoperative hospital stay (A), hospitalization expense (B), and operation Time (C) in groups D and S. The postoperative hospital stay and the average operation time in group D was significantly shorter than that in group S (*p*-value <0.0001). The average hospitalization expense for patients in group D was lower (*p*-value <0.0001).

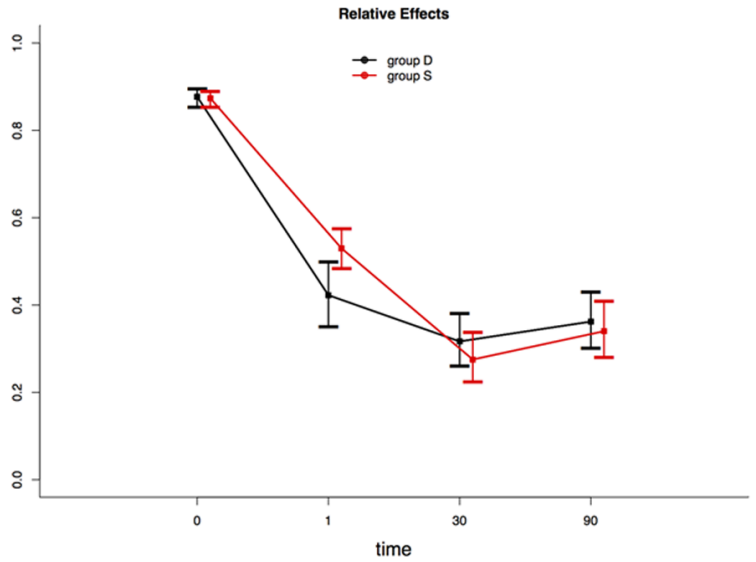

Figure 2. Comparison of NRS scores for patients from the two treatment groups. The NRS scores significantly decreased one day after the surgeries, and were lower at the 30th day after the surgeries. The changes of NRS scores over time were significant (*p*-value <0.0001). But there was no significantly difference between the average NRS scores of Group D and Group S (*p*-value = 0.6039). Time = 0: before surgery; Time = 1: 1 day after surgery; Time = 30: 30 days after surgery; Time = 90: 90 days after surgery.

PCN and ACDF resulted in similar, decreased NRS scores

The average NRS scores of Group D and Group S were not significantly different (*p*-value = 0.6039). **Figure 2** shows that the average NRS scores for patients in both groups were similar before the surgeries. The NRS scores significantly dropped one day after the surgeries, and were lower on the 30th day after the surgeries. The average NRS scores increased slightly 90 days after the surgeries. Overall, the changes of NRS scores over time were significant (*p*-value <0.0001).

The average NRS scores for the male and female patients were also compareed in group D and group S (**Figure 3**). The male and female patients in group D had similar average NRS scores except that male patients had higher average NRS scores than female patients 30 days after surgery. In group S, the male and female patients had similar average NRS scores before and one day after surgery, but the male patients had higher average NRS scores than the female patients 30 and 90 days after surgery, respectively. Overall, the average NRS scores between the male and female patients were not significantly different (*p*-value = 0.6555). There was no significant interaction effect between the treatment approaches and sex (*p*-value = 0.8174).

PCN and ACDF resulted in similar JOA scores

The JOA scores for the patients in the two treatment groups were compared (**Figure 4**). The average JOA scores for patients from group D and Group S were not significantly different (*p*-value = 0.8248). As shown in **Figure 4**, the JOA scores for patients in both groups stayed low and were close before surgery. But the JOA scores increased one day after the surgeries (time = 1). The JOA scores continued to increase 30 days after the surgeries (time = 30), but dropped at 90 days after the surgeries (time = 90). The changes of the JOA scores over time were significant (*p*-value <0.0001).

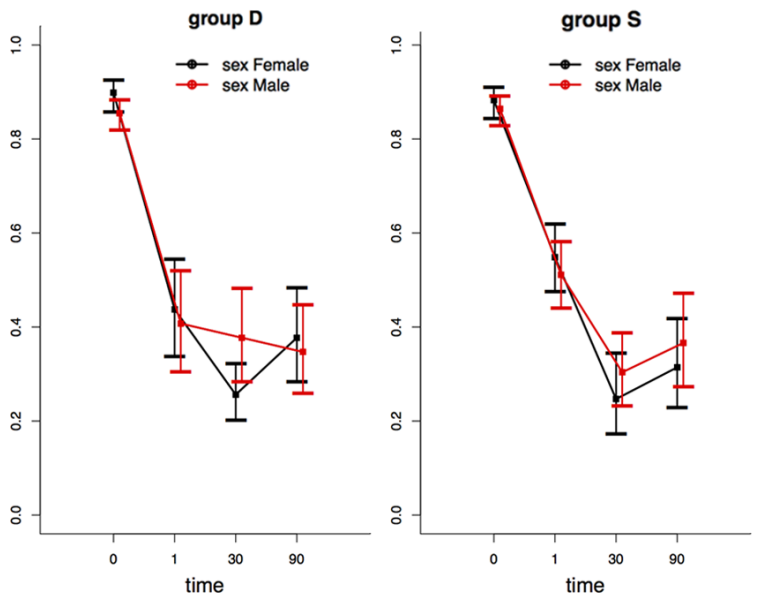

Figure 3. Comparison of NRS Scores for male and female patients from the two treatment groups. The male patients had higher average NRS scores than female patients at time = 30 in group D. In group S, the male patients have higher average NRS scores than the female patients at time = 30 and 90. The average NRS scores between the male and female patients were not significantly different (*p*-value = 0.6555). There was no significant interaction effect between treatment and sex (*p*-value = 0.8174). Time = 0: before surgery; Time = 1: 1 day after surgery; Time = 30: 30 days after surgery; Time = 90: 90 days after surgery.

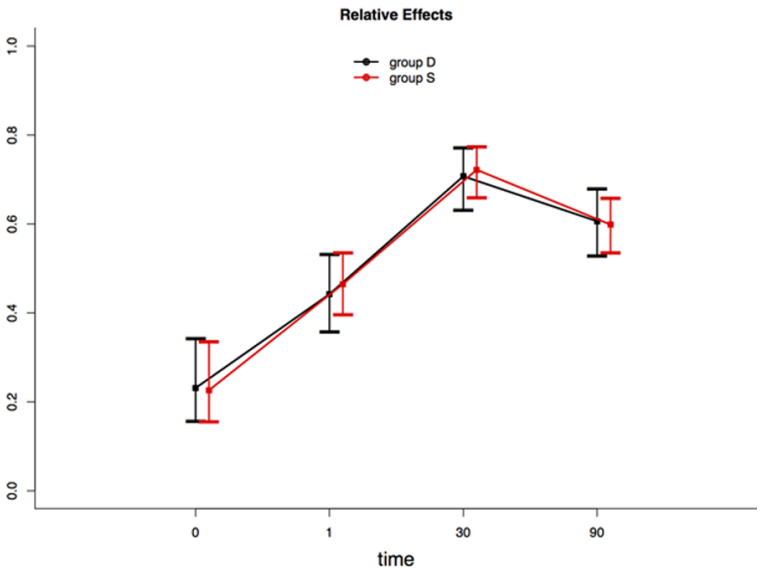

Figure 4. Comparison of JOA scores for patients from the two treatment groups. The average JOA scores for patients from group D and Group S were not significantly different (*p*-vaue = 0.8248). The JOA scores increased quickly one day after the surgeries (time = 1). The JOA scores continued to increase at 30 days after the surgeries (time = 30), but dropped at 90 days after the surgeries (time = 90). The changes of the JOA scores over time were significant (*p*-value <0.0001). Time = 0: before surgery; Time = 1: 1 day after surgery; Time = 30: 30 days after surgery; Time = 90: 90 days after surgery.

We then compared the average JOA scores for male and female patients in group D and in group S (**Figure 5**). We found that in group D the changes of JOA scores for the female and male patients had a same pattern, but the male patients had higher average JOA scores at each time points (time = 0, 1, 30 and 90). ANOVA test showed that the difference between the average JOA scores of the female and male patients in group D was significant (*p*-value = 0.0192). In group S, the average JOA scores for the female and male patients were similar at the four time points and there was no significant difference (*p*-value = 0.9526). Overall, the average JOA scores between the female and male patients were not significantly different (*p*-value = 0.0595). In addition, the interaction effect between sex and treatment was only marginal (*p*-value = 0.0710).

In summary, in terms of NRS and JOA scores, the two treatments approaches did not show significant differences. However, patients treated in group D had significantly shorter postoperative hospital stay and shorter operation time, and much lower expense. In addition, ANOVA test shows that there was no significant difference between the male and female patients in NRS and JOA scores. However, in group D, male patients have significantly higher average JOA scores than the female patients. Large sample might be needed to verify such difference.

Complications

No complications were observed in both two groups.

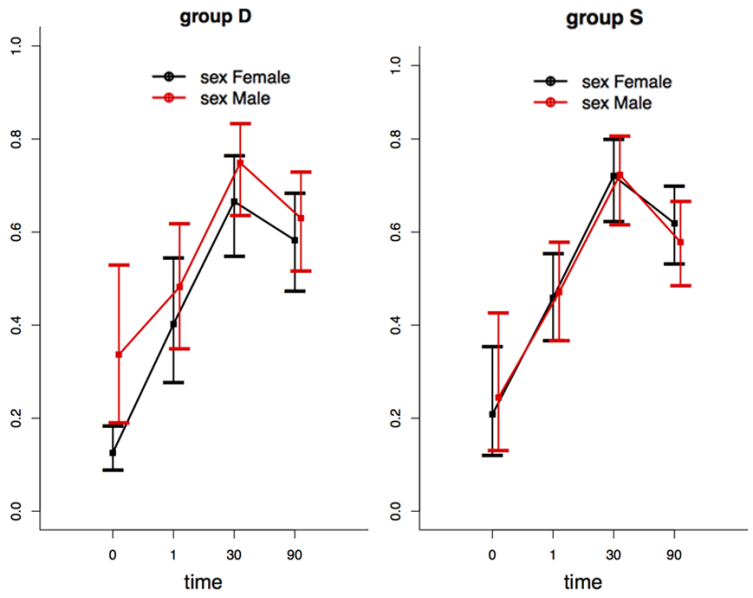

Figure 5. Comparison of JOA scores for male and female patients from the two treatment groups. ANOVA test showed that the difference between the average JOA scores of the female and male patients in group D is significant (*p*-value = 0.0192). In group S, there was no significant difference between the average JOA scores for the female and male patients (*p*-value = 0.9526). Overall, the average JOA scores between the female and male patients were not significantly different, but marginal (*p*-value = 0.0595). In addition, the interaction effect between sex and treatment was marginal (*p*-value = 0.0710). Time = 0: before surgery; Time = 1: 1 day after surgery; Time = 30: 30 days after surgery; Time = 90: 90 days after surgery.

Discussion

CDH is associated with fibrous ring rupture, nucleus pulposus protrusion or bulging because of disc degeneration, and mostly leads to radicular pain, dermatomal paresthesia and neurologic deficit. Traditional anterior or posterior disc fusion and Percutaneous Coblation Nucleoplasty (PCN) were commonly used for treatments in recent years. Anterior cervical discectomy and fusion (ACDF) is a major treatment and have been proved useful and high success rate by a number of studies [9-11]. However, in the present study, we found that the NRS scores on the 1th day, 30th day and 90th day after the surgeries were significantly decreased among patients administrated by PCN, which had no significant difference compared to those that received ACDF, indicating that PCN and ACDF have the similar effect. The reasons might be that PCN has produced a plasma layer in intervertebral discs by bipolar radiofrequency vaporization rod and interrupted the nucleus pulposus of organic molecular bonds, which reduced stress on nerve roots, arteries and spinal cord [12, 13] and relieved symptoms [14-16] and that PCN was more effective because cervical discs were relatively small, making the treatment get more reliefs of the posterior nerve roots and spinal canal.

There was increase of NRS scores and decrease of JOA scores at the 90th day after surgery but still significant changes compared to those before surgery. Several reasons can explain this clinical outcomes. Recovery of neural function is not a gradual improvement process, there are ups and downs [17]. Reduction of intervertebral space height after operation. The purpose of implanting titanium plate is to prevent the loss of the height of intervertebral space, but some literatures [18, 19] showed that there exist cervical anterior column height loss and physiological curvature loss in varying degrees after ACDF. This may be related to the collapse of graft bone, which occurred mainly in the 3 months after operation, come from the absorption and compression of the graft bone [20]. Cervical disc herniation and the degeneration of facet joint is mainly caused by the asymmetric mechanical stress on the cervical spine [21]. Some of the daily behavior, including long time working, will lead to this kind of asymmetric mechanical stress on the cervical vertebra. The surgery did not fuse the segment which got PCN and its adjacent segments, so degeneration will be continued. According to the ACDF, the currently mainstream view is to accelerate the degeneration of adjacent segments [22]. Spinal epidural scar and adhesion is the basic pathological changes after spinal surgery, intraoperative damage of fiber ring and posterior longitudinal ligament will produce scar and adhesion in the postoperative recovery. The adhesion of organization could produce symptoms by wrapping, stretching and squeezing nerve root. So, ACDF in our study that resected

the posterior longitudinal ligament and exposed the dual sac, would result in adhesion and scar, which would also cause the decrease of the JOA scores [23].

Although ACDF has been widely used in clinical practice, PCN and other minimally invasive surgeries have been getting more and more attention [24, 25] in recent years for milder injury. In this study, postoperative hospital stay, average hospitalization costs, and the operation time in PCN group were significantly less than those in ACDF. This was consistent with many previous studies [26], patients can recover faster, had less complications and less medical cost of hospitalization for slighter trauma. In the present study, patients did not appear complications and second-time surgery, but previous studies [27-29] showed that although ACDF's success rate and safety level are relatively high, the confining complications happened in perioperative and long-term were happened.

Alexander [30] found that ACDF might result in a transient dysphagia and hoarseness after operations. Other studies reported [31], muscle strength loss and cerebrospinal fluid leakage occurred after ACDF. In the otherwise, ACDF has increased the stability of the cervical spine and decreased part of the function of the cervical spine, which would accelerate the speed of adjacent segment degeneration [32, 33]. The long-term outcome of patients dealt with ACDF is determined by the rate of adjacent segment degeneration (adjacent segment syndromes) [34]. Compared with ACDF, PCN had less complications and slighter loss of disc height [35].

In addition, male patients of PCN have significantly higher average NRS scores 30 days after surgery than the female patients; meanwhile the male patients of ACDF also have higher average NRS scores than the female patients 30 days and 90 days after surgery. Previous studies, no matter short-term or long-term efficacy, showed no observation on the sex difference. Studies on comparing levels of post-procedural or post-surgical pain in women and men have shown inconsistent results, since sex differences in the delivery, effectiveness or both of pain treatments in clinical samples could also influence the presence, magnitude and direction of sex differences in pain severity [36]. Various reasons have been proposed but remain unclear and believed to be complex. The phenomenon here may result from the diversity of pain threshold, sensitivity and psychological state and cultural or population difference. It is probable that the reason is linked to the difference between female and male. First of all, female patients usually had experienced more physical pain, such as delivery, dysmenorrhea, and they have a higher pain threshold [37]. Secondly, pain is a kind of subjective feeling. Due to the function of estrogen, women are more sensitive to the pain intensity, they may be more sensitive to changes in pain relief [38]. Thirdly, the way to deal with pain is different [39]. Women are more likely to communicate with others and seek help from others. Communication with doctors, friends and family will be helpful in the treatment of pain. Other unknown physical and psychological factors may also be involved. Nevertheless, because of the limitation of sample size in this study, collecting more cases for further research is needed.

In this study, patients in two groups had no significant difference in the level of the intervertebral disc and the treatment effect. But other study also showed that ACDF was better choice for patients with protrusion of intervertebral disc and prolapse patients and multi segmental lesions [40].

In summery, percutaneous coblation nucleoplasty and anterior cervical discectomy and fusion were effective for the treatment of CDH. Comparing with anterior cervical discectomy and fusion, percutaneous coblation nucleoplasty has milder injury and earlier recovery.

Disclosure of conflict of interest

None.

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