**Original Article**

**Efficacy of coblation annuloplasty combined with nucleoplasty in cervical discogenic and radicular pain**

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**Abstract:** Background: Cervical discogenic pain and radicular pain often appear concurrently. Discogenic pain can be treated with thermal annular procedures that interrupt annular nociceptors, and radicular pain can be treated by decompression of nerve roots; however, there are no effective therapeutic approaches for treating patients with concurrent discogenic pain and radicular pain. Objective: This study aimed to evaluate the efficacy of coblation annuloplasty combined with nucleoplasty in treating cervical discogenic pain with concurrent radicular pain. Methods: This was a prospective, clinical, observational study of 20 patients with cervical discogenic and radicular pain related to contained disc herniation. Patients received coblation annuloplasty combined with nucleoplasty. Pain was assessed via the visual analogue scale (VAS) (significant pain relief was defined as VAS improvement ≥ 50%), and functional outcome was assessed using the modified MacNab criteria. All patients had 12 months of follow-up. Results: General, discogenic and radicular VAS scores significantly decreased from respective preoperative values of 7.9 ± 0.7, 6.2 ± 1.0 and 7.7 ± 0.9 to 3.1 ± 1.1, 2.6 ± 1.5 and 2.5 ± 2.0, respectively at 12 months postoperatively. Significant relief of general, discogenic and radicular pain at 12 months postoperatively was reported in 15 (75%), 17 (85%) and 15 (75%) patients, respectively. At postoperative 1, 3, 6 and 12 months, an “excellent” or “good” functional outcome was reported in 16 (80%), 16 (80%), 15 (75%) and 15 (75%) patients, respectively. Conclusions: Coblation annuloplasty combined with nucleoplasty effectively treated patients with cervical discogenic pain and concurrent radicular pain.

**Keywords:** Cervical disc herniation, discogenic pain, radicular pain, coblation, nucleoplasty, annuloplasty, thermal annular therapy

**Introduction**

Cervical discogenic pain and radicular pain are the most common ailments related to degenerative cervical disc disease in modern industrial society; both conditions seriously reduce quality of life and bring about enormous socioeconomic burden [1, 2]. Pain related to degenerative disc disease is generally managed using the stepladder treatment approach from conservative therapy to minimally invasive techniques to spinal fusion [3]. Among the various minimally invasive techniques, thermal annular procedures treat discogenic pain through interruption of nociceptors in the annulus [4, 5], and disc decompression treats radicular pain through decompression of nerve roots [6-8]. However, there is no one standard effective therapeutic approach to treat patients with discogenic pain and concurrent radicular pain.

To treat patients with discogenic pain and concurrent radicular pain, a therapeutic approach combining a thermal annular procedure and disc decompression was proposed in 2002 [9]. Patients with lumbar discogenic pain and concurrent radicular pain were treated by intradiscal electrothermal therapy (IDET) combined with coblation nucleoplasty, but no additional benefit was observed in clinical efficacy compared with IDET alone [9]. Another study using IDET plus coblation nucleoplasty to treat this type of pain had a similar clinical outcome [10]; the IDET alone was far superior to the combination of the two techniques [10]. Therefore, IDET and coblation nucleoplasty are potentially incompatible.

There is still a need to determine one effective therapeutic approach to treat patients with concurrent discogenic and radicular pain, especial-
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Table 1. Demographic characteristic

<table>
<thead>
<tr>
<th>Gender N (%)</th>
<th>Male</th>
<th>7 (35)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>13 (65)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>Mean ± SD</td>
<td>50 ± 8</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>33-63</td>
</tr>
<tr>
<td>Pain VAS score</td>
<td>General</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>6-9</td>
</tr>
<tr>
<td></td>
<td>Discogenic</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>5-9</td>
</tr>
<tr>
<td></td>
<td>Radicular</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>7-9</td>
</tr>
<tr>
<td>Duration of pain (years)</td>
<td>Mean ± SD</td>
<td>4 ± 2</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>1-10</td>
</tr>
<tr>
<td>Treated Level N (%)</td>
<td>C4/5</td>
<td>4 (20)</td>
</tr>
<tr>
<td></td>
<td>C5/6</td>
<td>16 (80)</td>
</tr>
</tbody>
</table>

or reflex, unresponse to conservative management including medication, physical therapy and epidural injection therapies, and a positive one-level provocation discography, revealed at least 7 of 10 concordant pain at the abnormal disc along with a normal adjacent control disc.

Exclusion criteria

Patients affected by coagulopathy, disc herniation with sequestration, infection, spinal instability, spinal fractures, tumor, advanced spondylosis resulting on osseous foraminal stenosis or disc space collapse, previous spinal surgery on the same level, uncontrolled psychological disorders.

Coblation procedure

The procedure was performed in an operating room using sterile technique. The patient was placed in supine position on the operation table, a 10 cm cushion was placed under the shoulder to keep neck slightly hyperextended and received the vital sign monitoring. Before procedure, an intravenous injection etimicin 1.0 g was administered as a prophylactic antibiotic. Patients received intravenous injection fentanil 50 μg and able to respond if a nerve root was irritated by thermal or mechanical stimulation. Then, all procedures were performed under local anesthesia.

First, the puncture angle was confirmed under fluoroscopic guidance with anterior-posterior (AP) and lateral view. Second, an 18-gauge, 8-cm introducer needle was advanced via a left or right anterior approach to the target disc. During the puncture process, introducer needle was inserted slowly and the advancement was stopped immediately when movement or paresthesia was occurred in patient’s upper limb. Once the introducer needle entered into the cervical disc, the advancement should be slowly until the tip reached to the opposite posterior annulus/nucleus junction and the position of tip should be checked carefully in AP and lateral view. Third, the coblation wand (UNITEC, China America United Technology (Beijing) Co. Ltd, China) was inserted into the introducer needle until the its tip was extended approximately 5 mm beyond the tip of the needle in order to ensure that the active portion of wand
was deployed into the annulus [16], and the position of wand tip was checked in AP and lateral view again. Fourth, coagulation was tested with the radio-frequency controller set at 2’ for 1/2-1 second to check that there was no movement or paresthesia in the patient’s upper limbs. Fifth, coablation mode was carried out with the radio-frequency controller set at 2’ of intensity for 1-10 seconds to ablate disc materials by rotating the wand 360°. Then, coagulation mode was carried out with controller set at 2’ of intensity for 1-2 seconds to denature adjacent materials and seal channel. After this, the tip of introducer needle was retreated to the anterior annulus/nucleus junction center of disc and the active portion of wand was inserted into the nucleus, and the position of tip is checked carefully again in AP and lateral view. The coablation and coagulation modes were performed again following the above steps if no movement or paresthesia in the patient’s upper extremities was reported. After withdraw of the wand, 2 ml of 0.5% lidocaine was injected into the introducer needle tract. All patients took the bed rest in the supine position for 48 hours. After discharged from hospital, patients were advised to avoid strenuous activities.

### Therapeutic efficacy assessment

Clinical improvement of pain after coblation technology, as the primary outcome, was assessed with pain VAS score (ranging from 0 to 10) at 1 week, and 1, 3, 6, 12 months postoperatively. The following variables were recorded as the secondary outcomes: significant (≥ 50%) pain relief was recorded at 1 week, and 1, 3, 6, 12 months postoperatively; patient’s function status was evaluated with “excellent”, “good”, “fair” and “poor” according to the Modified MacNab criteria at 1, 3, 6 and 12 months postoperatively; pain medication intake was assessed at 1, 3, 6 and 12 months postoperatively; pain medication intake was assessed at 1, 3, 6 and 12 months postoperatively; pain medication intake was assessed at 1, 3, 6 and 12 months postoperatively; pain medication intake was assessed at 1, 3, 6 and 12 months postoperatively. Finally, complications such as hemorrhages, paresthesia or infection were recorded.

### Statistics

Statistical analyses were performed by using GraphPad Prism version 5.0 (GraphPad Software Inc, San Diego, CA). Patient’s demographic and baseline clinical data were analyzed descriptively. The pain VAS score between the preoperative and postoperative time points
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was compared using repeated measures analysis of variance (ANOVA) test. The clinical results of significant pain relief, patients satisfaction and pain medicine intake were evaluated with the Wilcoxon sign rank test. A value of $P < 0.05$ was considered statistically significant in all analyses.

Results

Demographic characteristic

20 patients suffering from cervical discogenic pain and radicular pain received coblation annuloplasty and coblation nucleoplasty, male 7 and female 13. The mean pain VAS score was 7.7 ± 0.9 (ranging from 5-9), mean age was 50 ± 8 year-old (ranging from 33-63 year-old), and average duration of pain was 4 ± 2 years (ranging from 1-10 years). The C4/5 disc level was treated in 4 cases (20%), C5/6 in 16 cases (80%) with coblation technology (Table 1). The detailed information of location and quality of pain before operation was showed in Table 2.

Compared with 7.9 ± 0.7 of pre-operation, the general pain VAS score significantly decreased to 2.9 ± 1.7 (P < 0.05), 2.9 ± 1.3 (P < 0.05), 3.1 ± 1.3 (P < 0.05), 2.6 ± 1.4 (P < 0.05) and 3.1 ± 1.1 (P < 0.05) at post-operative 1 week and 1, 3, 6 and 12 months, respectively (Figure 1). And 16 (80%) patients reported significant (≥ 50%) pain relief at post-operative 1 week and 1 month, 16 (80%) at 3 and 6 months, and 15 (75%) at 12 months (Figure 2).

Compared with 6.2±1.0 of pre-operation, the discogenic pain VAS score significantly decreased to 2.2 ± 1.4 (P < 0.05), 2.1 ± 1.4 (P < 0.05), 2.2 ± 1.0 (P < 0.05), 2.2 ± 1.4 (P < 0.05) and 2.6 ± 1.5 (P < 0.05) at post-operative 1 week and 1, 3, 6 and 12 months, respectively (Figure 1). And 18 (90%) of patients reported significant (≥ 50%) pain relief at post-operative 1 week, 17 (85%) at 1 and 3 month, and 16 (80%) at 6 and 12 months (Figure 2).

16 (80%) patients reported a significant reduction (≥ 50%) in pain medicine intake at post-operative 1 and 3 months, 15 (75%) patients at 6 and 12 months (Figure 3). 16 (80%) patients didn’t take pain medicine at post-operative 1 month, 15 (75%) at 3 and 6 months, and 14 (60%) patients at 12 months.

6 (30%) patients reported soreness and 3 (15%) patients experienced ecchymoma at the...
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Discussion

Coblation annuloplasty combined with coblation nucleoplasty significantly decreased pain intensity, significantly improved functional status, and markedly reduced pain medication intake in patients with cervical discogenic pain and concurrent radicular pain after 12 months of follow-up.

Coblation nucleoplasty has been performed to treat pain related to degenerative cervical disc disease for over a decade [21]. This technique ablates nucleus material and decompresses nerve roots, resulting in significant improvement in cervical radicular pain [18, 20]; a 2006 study investigating the feasibility, safety and efficacy of coblation nucleoplasty in 55 patients with radicular pain related to contained disc herniation reported a significant improvement in pain VAS score and functional status over a 29-month period [20], and a 2010 study investigating coblation nucleoplasty in 47 patients with radicular pain related to contained disc herniation reported that VAS score and neck disability index were significantly improved after 24 months of follow-up [18]. However, clinical efficacy data of coblation nucleoplasty in treating cervical discogenic pain are limited.

To date, cervical discogenic pain has only been considered as a secondary symptom to be evaluated after coblation nucleoplasty treatment [15, 16, 19]; this has made it difficult to confirm the therapeutic role of coblation nucleoplasty in treating cervical discogenic pain. Because the major origin of discogenic pain has been confirmed as the innervated outer annulus, not the nerves growing into the nucleus along annular tears [22], the therapeutic role of coblation nucleoplasty in treating discogenic pain is uncertain.

Two previous studies investigated the use of coblation nucleoplasty combined with IDET to

Figure 2. Proportion of patients expressed significant (≥ 50%) relief in general, discogenic and radicular pain at post-operative 1 week, and 1, 3, 6 and 12 months.

Figure 3. Proportion of patients expressed “excellent” or “good”, “fair” and “poor” at post-operative 1, 3, 6 and 12 months.
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alleviate radicular pain and discogenic pain simultaneously [9, 10]; however, this approach was only assessed in lumbar degenerative diseases. This may be because the relatively narrow anatomic structure of the cervical spine compared with the lumbar spine can lead to technical difficulties and potential heat injury to cervical nerve roots during IDET [5, 23]. Unlike IDET, coblation technology is not a heat-driven process. A thermal mapping study in the porcine model showed that the subject’s skin temperature during coblation decreased from 20°C to 0°C when the distance from the tip of the wand was increased from 1 mm to 5 mm [24]; the radius of the thermal zone of coagulation is approximately 1 mm when the wand is moved at a speed of 0.5 cm/s [25]. These temperature properties indicate that coblation annuloplasty should be a reasonable complementary treatment for cervical discogenic pain.

In the present study, concordant pain during coblation annuloplasty or nucleoplasty was reported by eight and five patients respectively. The concordant pain was located mainly in the neck, back, scapular and shoulder, but not over the elbow joint; this is similar to the characteristics of cervical discogenic pain described in a previous study [26]. The provocation of concordant pain may be owing to interruption of nerves in the nucleolus or annulus during ablation and coagulation, indicating that coblation annuloplasty and nucleoplasty are complementary approaches that interrupt the nerves involved in cervical discogenic pain. In the present study, 80% of patients reported significant relief of discogenic pain at 12 months postoperatively. These encouraging clinical outcomes are potentially the result of the combination of coblation annuloplasty and nucleoplasty.

Unlike discogenic pain, radicular pain was not provoked during coblation annuloplasty or nucleoplasty in the present study. If radicular pain (radiation of electric shock-type pain into the fingers [26]) was experienced during the procedure, the procedure would have been stopped. This is because the principle in treating radicular pain is to depress, but not irritate, the nerve root [7]. In the present study, 75% of patients reported significant relief of radicular pain at the 12-month follow-up. Although similar positive clinical outcomes using coblation nucleoplasty to treat cervical radicular pain have been published [18, 20], it is hard to determine whether the clinical efficacy originated from coblation nucleoplasty in the present study. The significant pain relief could potentially be owing to coblation annuloplasty alone or to the combination of annuloplasty with nucleoplasty; further research is needed to investigate this.

In the present study, six patients experienced soreness and three patients experienced ecchymoma at the needle insertion site, but the symptoms had completely disappeared by 2 weeks after surgery. Soreness and ecchymoma are the most commonly reported side effects of coblation technology [27]. No haemorrhage, paraesthesia or infection were observed in our study.

There were some limitations to the present study. First, there was no control or placebo; this was because conducting a blinded, randomised, placebo-controlled study was prohibitively expensive and logistically difficult in a practice setting. The efficacy of coblation annuloplasty or nucleoplasty in treating cervical discogenic and radicular pain should be evaluated separately in future research. Second, the sample size was small and may not be generalisable to all patient populations; however, our study will help to provide a preliminary framework for the planning of future prospective, randomised, controlled studies. Third, coblation annuloplasty or nucleoplasty itself is a blind technique, so it was difficult for the physician to completely deploy the tip of the wand in the annulus or nucleolus; the phrase “coblation annuloplasty” or “coblation nucleoplasty” was a more accurate description of the procedure used in this study.

Conclusion

The approach of coblation annuloplasty combined with nucleoplasty significantly improve pain intensity and functional status in patients with cervical discogenic and radicular pain, which is an effective, safe, minimally-invasive and less uncomfortable procedure.

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Disclosure of conflict of interest

None.
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