Editorial

Percutaneous cervical laser diskectomy, thermoannuloplasty, and thermonucleoplasty; comparable results without surgery

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Abstract

Background: Utilizing the literature, the results of three different minimally invasive surgery (MIS) anterior cervical percutaneous operations for neck/mild radicular pain and magnetic resonance (MR)-documented “contained” (not extruded/sequestrated) discs were evaluated. Results were compared with patients treated nonsurgically for comparable/greater neurological compromise, and even more severe cervical disc disease.

Methods: There were three MIS percutaneous anterior cervical discectomy procedures. Anterior cervical laser discectomy ablated and vaporized disc tissue. The thermoannuloplasty used heat to contract collagen fibers to reduce disc volume. Thermonucleoplasty employed a low-temperature resister probe to promote disintegration and evacuation of small volumes of disc (e.g., some studies cited an average of just 0.09 mL of disc removed). These results were compared to those for the nonsurgical management of patients with comparable/greater neurological deficits, and more severe cervical disc herniations.

Results: The three MIS anterior cervical operations resulted in 80–90%+ improvement using Macnab’s criteria. However, although the literature demonstrated similar 80–90%+ improvement without cervical surgery, the latter patients were more neurologically compromised.

Conclusions: For patients with pain alone/mild radiculopathy and “contained” discs on MR, three MIS percutaneous anterior cervical disc operations resulted in 80–90%+ improvement. Notably, similar 80–90%+ improvement was observed for comparable/more neurologically impaired patients with even larger cervical disc herniations treated nonsurgically. With such findings, where is the “value added” for these three MIS cervical operations?

Key Words: Cervical, laser discectomy, minimal indications, cervical nucleoplasty, percutaneous, thermoannuloplasty
INTRODUCTION

Utilizing the literature, outcomes of three percutaneous minimally invasive surgery (MIS) anterior cervical operations were evaluated. Patients presented with neck pain/mild radiculopathy and MR-documented “contained” (e.g., neither extruded or sequestrated) cervical disc herniations. The anterior cervical laser discectomy ablates, vaporizes, and decompresses the posterior/central nucleus pulposus. The thermoannuloplasty heats the posterior disc near the annulus, producing contraction of collagen fibers, and thereby, reduces the disc volume. The thermonucleoplasty low-temperature resister probe promotes disintegration and evacuation of disc material (e.g., reported in some studies to average just 0.09 mL) [Tables 1–4]. Results of these three procedures were compared to the literature for patients with comparable/more severe cervical disc disease and greater neurological impairment treated. Of interest, outcomes for both the operative and nonoperative groups were similar, demonstrating 80–90%+ improvement utilizing Macnab’s criteria (good/excellent outcomes) [Tables 1–5]. With such findings, where is the value added” for the three MIS cervical operations?

Early clinical and animal studies for minimally invasive anterior cervical laser disc ablation

Between 1995–1998, three studies evaluated the early experience with cervical laser disc ablations in patients with pain alone/mild radiculopathy without focal neurological deficits for “contained cervical discs” [Tables 1 and 2].[6,21,23] Siebert et al. (1995) treated 31 patients with cervical percutaneous laser disc decompression (PLDD)/ablation initially with a Nd:YAG laser (1990), followed by the Ho:YAG laser (1991-1993); 28 of 31 patients experienced pain relief 6 weeks later [Table 2].[23] Turgut et al. (1997) later documented the damage produced by the neodymium YAG laser (Nd:YAG laser) to the vertebral end-plates in 32 guinea pigs (randomly divided into a control group, and the Nd:YAG laser group) [Table 2].[23] Subsequently, in a large nonrandomized, non-blinded clinical series, Choy (1998) evaluated 752 PLDD performed in 518 patients over a 12-year period [Table 2].[6] The author claimed the laser removed a small volume of disc material sufficient to drop intradiscal pressure, allowing for the “disc to move away from the nerve root,” resulting in a 94.5% incidence of good-to-excellent results [Table 1].

Comparsom efficacy of two lasers for anterior cervical disc ablation

In 2000 and 2001, Knight et al. documented that two lasers were comparably effective in performing anterior cervical laser disc ablations in patients with neck pain alone with MR-documented “contained” discs [Table 2].[12,13] Using one of two side-firing laser probes (e.g., the Holmium 2100: YAG versus KTP532 laser), they performed 108 procedures in 105 patients (note no control group); 1 year postoperatively (minimum), 50% of patients demonstrated good/excellent outcomes.

Percutaneous laser discectomy, thermoannuloplasty, thermonucleoplasty

Several studies utilized percutaneous laser discectomy, thermoannuloplasty, or thermonucleoplasty to treat patients with pain alone/mild radiculopathy and MR-documented “contained” discs; in these series, patients exhibited 85–88.3% improvement [Tables 2 and 3].[1,3,14,15,17] Ahn et al. (2004) performed 11 anterior percutaneous cervical discectomies (PCD) using an endoscope/Ho:YAG laser; 88.3% improved [Table 2].[1] Bonaldi et al. (2006) performed anterior cervical thermoannuloplasty in 55 patients using the Perc-DC SpineWand; at 6 months 85% improved [Table 2].[8] In 2006, Lee et al. evaluated 60 cervical PLDD [Ho:YAG laser assisted spinal endoscopy (LASE)]; 85.0% (51 patients) improved [Table 2].[14] Li et al. (2008) used the Perc-D Spine Wand in 126 patients; 87.3% improved [Table 2].[17]

One commercial device for percutaneous laser disc ablation

In two studies without control groups, Deukmedjian et al. (2012, 2013) introduced the Cervical Deuk Laser Disc Repair® for percutaneous laser disc ablation utilized in patients with pain/mild radiculopathy and “contained discs” [Table 3].[9,10] In 2012, they operated on 142 adults and found, over 4 years, all patients were “successfully treated without any complications.” Notably, however, the mean volume of disc material removed was just 0.09 mL. In their second study (2013) they used the same device in 66 consecutive patients undergoing 1–2 level cervical disc operations; pain improved over 3 postoperative months in 94.6% of patients, and there were no adverse events [Table 3].[10]

Minimal changes in disc height or variable improvement following anterior cervical laser discectomy or thermonucleoplasty

Three studies looked at the results of anterior cervical percutaneous laser discectomy or nucleoplasty [Table 3]. Ren et al. (2013) found no alternation of
Table 2: Percutaneous cervical laser discectomy 1995-2010

| Reference Year | Number patients Cervical surgery | Surgical levels Duration Follow-up | Results Outcomes | Outcome measures | Outcomes Conclusions |
|----------------|----------------------------------|------------------------------------|------------------|------------------|---------------------|
| Li[17] 2008    | 126 contained cervical discs     | PCDN                               | Outcomes:        | Macnab           | No AE (1 needle broke in disc space) Safe and effective |
|                | Average 51.9-year-old Perc-D SpineWand (Bias) | Levels:                          | Pain reduction  | 62 Excellent  | 87.3% (23 Fair) VAS: 1 yr. improved |
|                |                                  | 21 C34                             | X-rays: no instability | 85% Good/   | MIS preserved |
|                |                                  | 30 C45                             |                  | Excellent       | anterior structures/ |
|                |                                  | 40 C56                             |                  | Retained stability |                |
|                |                                  | 35 C67                             |                  |                  |                  |
| Lee[19] 2007   | PECO/Working channel endoscope   | PECD/PECA                          | Percutaneous cervical stabilization (PCS) did not completely replace fusion | AE: 1 Diskitis | Cervical plasma |
|                | HD:YAG: Laser                    | End firing laser avoids neural injury |                  | Rupture device tip | radiofrequency |
|                | Decompression                    |                                   |                  | Concluded:      | discectomy MIS        |
|                | Annuloplasty                      |                                   |                  | Low Risk         | Safe/effective       |
| Bonaldi[21] 2006 | 55 plasma Radiation laser discectomies Followed 29 mos. | Perc-DC SpineWand (Commercial bias) Obscurred Local anesthesia | Macnab Criteria 6 mos.: 85% (52/55) Good/excellent 2/3 Myelopathy improved | AE: 1 Diskitis | Cervical plasma |
|                | 3 myelopathy                      |                                   |                  | 1 Rupture device tip | radiofrequency |
|                |                                  |                                   |                  | Concluded:      | discectomy MIS        |
|                |                                  |                                   |                  | Low Risk         | Safe/effective       |
| Lee[14] 2006   | 60 cervical PLDD Ho:YAG LASE     | Contained cervical soft disc       | Followed 71 mos VAS Better 7.9 to 2.6 | Macnab Criteria” | Pain relief 19 patients |
|                |                                  |                                    |                  | 85% Good/ Excellent | Long-term success |
| Ahn[1] 2004    | 111 PCD Endoscopic Ho:YAG Laser  | Followed mean 49.4 mos. Local anesthesia | Macnab criteria: 46.9% Excellent 33.3% good 8.1% fair 11.7% Poor | 88.3% Improved | Radiculopathy |
|                | Soft discs                        |                                    |                  | Positive prognostic factors | Lateral discs |
|                |                                  |                                    |                  |                  | Good patient selection |
| Knight[12] 2000 | 105 patients Outpatient Cervical PLDD for discs | MR Broad based discs | Also used provocative discography to isolate surgical levels | Anterior approach | Good outcomes |
|                | 108 levels                        |                                    |                  | Side firing probes |                  |
|                | Outpatient                        |                                    |                  |                  |                  |
|                | Cervical PLDD                     |                                    |                  |                  |                  |
|                | 25 mos                            |                                    |                  |                  |                  |
| Chiu[5] 2000   | 200 PECO Lower energy laser       | Disc Disease Radiculopathy MR or CT | Outcomes; 94.5% Good/ excellent 11% Neck pain/paresthesias | No AE | 94.5% Good/Excellent outcomes |
|                | Thermodiskoplasty                 |                                    |                  | Average 10 days return to work | Safe |
|                | Followed average 25 mos           |                                    |                  |                  | Effective |
| Choy[16] 1998  | 752 Procedures 518 Patients       | 12 years Local anesthesia Fluoroscopy | Theory: sharp fall in intradiscal pressure with small amount of disc removed | Choy claimed introduced this in 1984 | Success rate: 75-89% |
|                |                                  |                                    |                  |                  | Less than 1% AE |
| Turgut[23] 1997 | PLDD Cervical Animal Model Damage end plates with laser Nd:YAG (Cervical) | 32 guinea pigs Group I: Control Group II: Experimental with Laser | Studied disc degeneration at three levels Re-explored 2 mos. postop anterior surgery | Group II: re-exploration Nd:YAG laser disc radiation o | Significant between groups due to the laser |
|                |                                  |                                    |                  |                  | Unproven benefit of laser Added risks |
| Siebert[21] 1995 | 31 PLDD Cervical Discs 1991-1993 | First few patients: Nd; YAG laser No AE | Since 1991 latter patients: Ho:YAG Laser | 28/31 pain relieved 6 weeks post procedure | Cervical PLDD “Viable therapy” for disc disease |

Cervical Discectomy, PCDN: Percutaneous cervical discectomy/nucleoplasty, HNP: Herniated nucleus pulposis, JOA: Japanese orthopedic association score, PECO: Percutaneous endoscopic cervical discectomy, VASL: Visual analog scale, NDI: Neck disability index, PELD: Percutaneous endoscopic laser disc decompression, PCFD: Percutaneous cervical foraminotomy discectomy, EBL: Estimated blood loss, PLL: Posterior longitudinal ligament, yrs.: Years, PTLD: Percutaneous thoracic laser discectomy, AE: Adverse events, PECO: Percutaneous endoscopic cervical discectomy, WSH: Working channel endoscope, Ho:YAG: Holmium:yttrium-aluminium-garnet, PECA: Percutaneous endoscopic cervical annuloplasty, PCS: Percutaneous cervical stabilization, ACDF: Anterior cervical discectomy/fusion, mos: Months, LASE: Laser-assisted spinal endoscopy, PCD: Percutaneous cervical discectomy, avg.: Average

Lee and Lee (2014) documented 37 patients undergoing percutaneous cervical laser disc ablations (no control
### Table 3: Percutaneous cervical laser diskectomy 2012-2014

| Reference      | Year  | Number patients | Cervical surgery                        | Surgical levels Follow-up | Results | Outcome measures | Outcomes |
|----------------|-------|-----------------|-----------------------------------------|----------------------------|---------|------------------|----------|
| Wullems[26]    | 2014  | Review 823 PCN/1021 patients 10 articles | MEDLINE, EMBASE, Cochrane Library | All studies; Low quality methods: except 2 | Concluded; PCN safe effective all durations | Low/Moderate clinical relevance |
| Yang[27]       | 2014  | 171 Patients 3 MIS: 2003-2011 97 PCD 50 PCN 24 PCDN | Followed years: 4.1 PCD 2.6 PCN 3.3 PCDN | Same JOA scores PCD 21.8 PCN 14.5 PCDN 8.5 | Same Odom’s criteria 81.5% 82.44% 83.1% | Good outcomes Safe/effective MIS No instability |
| Lee[16]        | 2014  | 37 PECD No Fusion Followed 45.5 mos | Loss disc height Increased Degeneration | VAS Score: Neck 6.3-7.5 Arm 2.7-2.6 >NDI 46.8-17.2% | Lack of fusion with PECD | No fusion- No negative impact on outcome |
| Deukmedjian[10] | 2013  | 66 Patients Deuk Laser Disc Repair(®) Followed 94 days (mean >3 mos.) Endoscopic “repair” of cervical discs” | 1-Level 21 2-Level 45 (Adjacent) 94.6% Significant improvement | Similar outcomes <or >90 days VAS significantly improved: From 8.7 to 0.5 | No AE; only 1 recurrent disc | Safe and effective alternative to ACDF or arthroplasty 94.6% Success 1-2 Level Cervical Disease Commercially biased study |
| Ren[20]        | 2013  | 22 PLDD Cervical and lumbar discs | PLDD reduced disc herniation Address: PLL, endplates, annulus, foramina, HNP | PLDD did not lower disc height significantly | PLDD safe and effective | PLDD valid for MIS/cervical and lumbar All successes; no AE Average disc removed: 0.09 ml |

PCN: Percutaneous cervical nucleoplasty, MIS: Minimally invasive surgery, PCD: Percutaneous cervical discectomy, PCDN: Percutaneous cervical diskectomy/nucleoplasty, HNP: Herniated nucleus pulposis, JOA: Japanese orthopedic association score, PECD: Percutaneous endoscopic cervical discectomy, VAS: Visual analog scale, NDI: Neck disability index, PELD: Percutaneous endoscopic laser diskectomy, PLDD: Percutaneous laser disc decompression, PCFD: Posterior cervical foraminotomy discectomy, EBL: Estimated blood loss, PLL: Posterior longitudinal ligament, yrs.: Years, AE: Adverse events

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### Table 4: Three randomized controlled trials utilizing cervical nucleoplasty coblation techniques

| Reference     | Year | Number patients | Cervical nucleoplasty Indications | Surgical levels Duration Follow-up | Results | Outcome measures | Outcomes |
|---------------|------|-----------------|----------------------------------|------------------------------------|---------|------------------|----------|
| Nardi[18]     | 2005 | 70 Contained cervical discs Cervical neck pain/radiculopathy | RCT: 20 Medical Rx, PT (CC) 50 NUC | 80% NUC Excellent Outcomes | 10% NUC Residual cervical pain/radicular pain Still under surveillance | 10% NUC Alternative traditional methods treatment |
| Birnbau[2]    | 2009 | 56 contained cervical discs-Nonherniated disc protrusions/prolapse Cervical neck pain/radiculopathy Perc DC-Spine Wand/Coblation | RCT: 30 Medical Rx, PT (CC) 26 NUC | Followed 2 years No complications | NUC VAS 2.3 Many Medical Rx/PT VAS 5.1 | Nucleoplasty Safe and effective at 2 years |
| Cesaroni[4]   | 2010 | 120 Symptomatic contained discs Cervical neck/arm pain/radiculopathy Plasma disc decompression/ coblation Perc DC-Spine Wand/Coblation | RCT: 58 Medical Rx, PT (CC) 62 NUC | Followed 1 year VAS NDI SF-36 Significantly better outcomes for NUC vs. CC | Outcomes NUC VAS -65.73 NDI -16.70 SF-36 8.86 Physical Component | Outcomes CC VAS - 36.45 NDI - 12.40 SF-36 4.24 Physical component |

RCT: Randomized control group, PT: Physiotherapy, Rx: Management, NUC: Nucleoplasty, VAS: Visual analog scale, CC: Conservative care, NDI: Neck disability index, SF-36: Short form 36
Group); all improved (e.g., using the neck disability index (NDI)) [Table 3].[16] Yang et al. (2014) compared the results for cervical percutaneous discectomy (97 cases), disc nucleoplasty (50 cases), and combined procedures (24 cases) (note; no control group); all resulted in comparable outcomes (Odom criteria) [Table 3].[12]

**Low/moderate clinical relevance of percutaneous cervical nucleoplasty/coblation**

Utilizing multiple databases to identify randomized clinical trials (RCTs), Wullems et al. (2014) evaluated the outcomes for patients with pain/mild radiculopathy and “contained” cervical discs undergoing percutaneous anterior cervical nucleoplasty/coblation [Tables 3 and 4].[12,18,26] Three randomized controlled trials (RCTs), and seven nonrandomized studies identified a total of 823 patients (≥892 disks) undergoing nucleoplasty/coblation [Table 4].[26] In the RCT by Nardi et al. (2005), 50 consecutive patients underwent nucleoplasty/coblation versus 20 patients treated nonsurgically; in the surgical group, 80% completely recovered, 10% had residual complaints, and 10% failed to improve [Table 4].[18] Notably, they observed less success for those managed nonsurgically. Using the PercCD-Spine Wand coblation technique, Birnbaum et al. (2009) compared outcomes for 26 patients undergoing surgery

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**Table 5: Favorable responses to nonsurgical treatment for cervical pain/radiculopathy**

| Reference Year | Number patients | Surgical levels | Results | Outcome measures | Outcomes |
|----------------|-----------------|-----------------|---------|-----------------|----------|
| Corniola[1] 2015 | Cervical disc herniation; | Compression of a root | Radiculopathy with/without sensory/motor deficit or myelopathy | Failure of medical treatment 6-8 mos. | Majority can be treated conservatively |
| Wong[25] 2014 | Literature Medline Embase Cinahl, SportsDiscus, Cochrane | 1221 Articles 8 Eligible 3 Low risk of bias: 2 Course 1 Prognosis | Symptomatic cervical discs/radiculopathy present with pain/ moderate disability | Natural Course; Much improved over 4-6 mos. | 83% Complete Recovery at 2-3 years with nonsurgical management |
| Cvetanovich[16] 2014 | 76 yo male Right upper extremity radiculopathy | Large cervical disc posterior to C6 vertebral body on MR | Intermittent traction=continuous traction No one method better than the other | Patients improved over time/ Natural course of the disease | Favorable outcome Without surgery |
| Thoomes[22] 2013 | Meta-analysis 15 articles 11 studies | 2 studies; low risk of bias Collar=PT Collar=traction Traction=placebo traction | Neck pain with/without radiculopathy or myelopathy | Low quality evidence showed surgery=effective vs. no surgery | No significant differences surgery vs. no surgery |
| Van Middelkoop[26] 2013 | Meta analysis 2013 RCTs 6 CCTs | Recovery of function with/without surgery | 6 weeks 75% favorably responded to nonsurgical treatment 78% (63 total pain relief) | Total pain relief; 3 could not tolerate 15 traction failed | Only 3 of 63 responding to traction required surgery |
| Oliver[19] 2002 | Halter Traction 81 Patients Cervical radiculopathy MR 78/81 Discs 71 Foraminal stenosis 7 | Average age 47 55 C7, 37 C6 2 C5 2 C8 deficits 81 trial of traction | MR/CT Discs: Soft 90% Hard 10% Completion of conservative physical and pharmacological Rx Followed average 5.5 yrs. | Motor deficit Improved 94.1 no surgery 50% surgery | Motor deficit Self rated: Not disabled 89.7% without surgery 66.7% with surgery Good/Better results without surgery |
| Heckmann[11] 1999 | 60 Cervical Discs Neck pain 93.3%, Sensory 88.3% Reflex 61.7% Motor 51.7% | No surgery 39 (65%) Surgery 21 (35%) Brachialgia 100% no surgery 95.1% surgery Sensory Resolved 97% no surgery 75% surgery | Motor deficit Improved 94.1 no surgery 50% surgery | Self rated: Not disabled 89.7% without surgery 66.7% with surgery Good/Better results without surgery |

RCT: Randomized controlled study, CCT: Controlled clinical trials, MRI: Magnetic resonance imaging, CT: Computed tomography, yrs.: Years, mos.=Months
versus 30 controls (randomized study) [Table 4].[3] Using the Visual Analog Scale (VAS), the average 2-year improvement for the surgical group was better (2.3) compared with the nonsurgical group (5.1). In the 2010, RCT by Cesaroni and Nardi, 62 patients were treated with the CD-Spine Wand versus a control group of 58 patients; 1 year later, the surgically treated patients exhibited better outcomes [Table 4].[4]

Review of comparable results for nonsurgical management of cervical discs

A review of multiple studies documented the successful nonsurgical management (e.g., up to 80–90%+ improvement) of cervical disc herniations in patients with pain alone/more severe neurological deficits, and larger cervical disc herniations [Table 5].[5,6,7,8,9] Heckmann et al. (1999) evaluated the results of conservative management for 60 patients with cervical discs; over an average of 5.5 years, 39 (65%) had no surgery versus 21 (35%) who had ventral discotecomies [Table 5].[10] Outcomes for both the nonsurgical versus surgical groups were nearly comparable in all categories. In 2002, Olivero and Dulebohn compared the efficacy of using a collar versus halter traction in the management of 81 patients with cervical radiculopathy; 75% of patients improved without surgery [Table 5].[11] Thoennes et al. (2015) also documented the success of conservative management (e.g., collar versus physiotherapy versus traction) for patients with radiculopathy and cervical disc herniations; they concluded “patients seem to improve over time, indicating a favorable natural course” [Table 5].[12] When van Middelkoop et al. (2013) performed a meta-analysis of adults with neck pain without radiculopathy or myelopathy, comparable results were observed with/without surgery [Table 5].[13] Wong et al. (2014) also confirmed the success of nonsurgical management of cervical disc herniations; patients substantially improved within 4–6 months, with 85% showing complete recoveries within 24–36 months. [Table 5].[14] In a case report, Cvetanovich et al. presented a 76-year-old patient with an acute right upper extremity radiculopathy and a large cervical herniation at the C6–C7 level; the patient fully recovered 7 months later and the MR documented full resolution of the disc herniation [Table 5].[15] Finally, in 2015, Corniola determined; “the majority of cervical disc herniations can be supported by means of (a) conservative treatment” [Table 5].[16]

CONCLUSION

Utilizing the literature, we compared the outcomes for patients with neck pain/mild radiculopathy and MR-documented “contained” cervical disc herniations treated with three MIS percutaneous anterior cervical operations versus those managed nonsurgically. Notably, those treated without surgery originally demonstrated even greater neurological deficits and radiographic/MR neurological compromise. For both groups, outcomes were comparably good/excellent up to 80–90%+ of the time. Since nonsurgical management was so successful in these patients, shouldn’t we question whether there is a “value added” or in fact, any value for the three MIS for any of the three MIS cervical disc operations under discussion?

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