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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

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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].[7,8,11,19,22,23] 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].[21] 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].

Table 1: Macnab's outcome criteria

Grade	Criteria
Excellent	No pain; no restriction of activity.
Good	Occasional back or leg pain of sufficient severity to interfere with the patient's ability to do his normal work or his capacity to enjoy himself in his leisure hours.
Fair	Improved functional capacity, but handicapped by intermittent pain of sufficient severity to curtail or modify work or leisure activities.
Poor	No improvement or insufficient improvement to enable increase in activities; further operative intervention required.

Comparable 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].[3] 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."[9] 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].[16,20,27] 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 Average 51.9-year-old Perc-D SpineWand (Bias)	PCDN Levels: 21 C34 30 C45 40 C56 35 C67	Outcomes: Pain reduction X-rays: no instability	Macnab 62 Excellent 41 Good 87.3% (23 Fair) VAS: 1 yr. improved	No AE (1 needle broke in disc space) Safe and effective
Lee[15] 2007	PECD/Working channel endoscope HO:YAG: Laser Decompression Annuloplasty	PECD/PECA End firing laser avoids neural injury	Percutaneous cervical stabilization (PCS) did not completely replace fusion	MIS preserved anterior structures/ retained stability	May reduce complications of typical ACDF
Bonaldi[3] 2006	55 plasma Radiofrequency cervical discectomies Followed 29 mos. 55 radiculopathy 3 myelopathy	Perc-DC SpineWand (Commercial bias) Outpatient Local anesthesia	Macnab Criteria 6 mos.: 85% (52/55) Good/excellent 2/3 Myelopathy improved	AE: 1 Diskitis 1 Rupture device tip Concluded: Low Risk	Cervical plasma radiofrequency discectomy MIS 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" 85% Good/ Excellent	Pain relief 19 patients Long-term success
Ahn[1] 2004	111 PCD Endoscopic Ho:YAG Laser Soft discs	Followed mean 49.4 mos. Local anesthesia	Macnab criteria: 46.9% Excellent 33.3% good 8.1% fair 11.7% Poor	88.3% Improved Positive prognostic factors	Radiculopathy Lateral discs Good patient selection
Knight[12] 2000	105 patients 108 levels Outpatient Cervical PLDD for discs	MR Broad based discs	Also used provocative discography to isolate surgical levels	Anterior approach Side firing probes	Good outcomes
Chiu[5] 2000	200 PECD Lower energy laser Thermodiskoplasty Followed average 25 mos	Disc Disease Radiculopathy MR or CT	Outcomes; 94.5% Good/ excellent 11% Neck pain/paresthesias	No AE Average 10 days return to work	94.5% Good/Excellent outcomes Safe Effective
Choy[6] 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, PECD: Percutaneous endoscopic cervical discectomy, VASL:Visual analog scale, NDI: Neck disability index, PELD: Percutaneous endoscopic laser discectomy, PLDD: Percutaneous laser disc decompression, PCFD: Posterior cervical foraminotomy discectomy, EBL: Estimated blood loss, PLL: Posterior longitudinal ligament, yrs.: Years, PTLD: Percutaneous thoracic laser discectomy, AE: Adverse events, PECD: 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

disc height before and after cervical and lumbar PLDD (all 22 patients with "contained" discs) [Table 3].[20] 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 Duration Follow-up	Results Outcomes	Outcome measures	Outcomes Conclusions
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 Mean 47.8 yrs. old	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	PLDD did not lower disc height significantly	PLDD safe and effective	PLDD valid for MIS/ cervical and lumbar
Deukmedjian[9] 2012	142 Cervical discs Cervical Deuk Laser Disc Repair(®) Commercial bias Endoscopy	Address: PLL, end plates, annulus, foramina, HNP	All patients candidates for ACDF Followed for 4 years	Offers partial discectomy foraminoplasty, posterior annular debridement	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

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

Reference Year	Number patients Cervical nucleoplasty Indications	Surgical levels Duration Follow-up	Results Outcomes	Outcome measures	Outcomes Conclusions
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/radiciulopathy Plasma disc decompression/ coblation Perc DC-Spine Wand/Coblation	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: Physical therapy, Rx: Management, NUC: Nucleoplasty, VAS: Visual analog scale, CC: Conservative care, NDI: Neck disability index, SF-36: Short form 36

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

Reference Year	Number patients Cervical surgery	Surgical levels Duration Follow-up	Results Outcomes	Outcome measures	Outcomes Conclusions No surgery
Corniola[7] 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[8] 2014	76 yo male Right upper extremity radiculopathy	Large cervical disc posterior to C6 vertebral body on MR	7 mos later Disc resorbed	Patient normal 2-year follow-up	Success conservative management cervical discs
Thoomes[22] 2013	Meta- analysis 15 articles 11 studies	2 studies; low risk of bias Collar=PT Collar=traction Traction=placebo traction	Intermittent traction=continuous traction No one method better than the other	Patients improved over time/	Favorable outcome -natural course of the disease Without surgery
Van Middelkoop[24] 2013	Meta analysis 20113 RCTs 6 CCTs	Recovery of function with/without surgery	Neck pain with/without radiculopathy or myelopathy	Low quality evidence showed surgery=effective vs. no surgery	No significant differences surgery vs. no surgery
Olivero[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	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
Heckmann[11] 1999	60 Cervical Discs Neck pain 93.3%, Sensory 88.3% Reflex 61.7% Motor 51.7%	MR/CT Discs: Soft 90% Hard 10% Completion of conservative physical and pharmacological Rx Followed average 5.5 yrs.	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

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].[27]

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].[2,4,18,26] 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

versus 30 controls (randomized study) [Table 4].[2] 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].[7,8,11,19,22,23] 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 discectomies [Table 5].[11] 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].[19] Thoomes *et al.* (2013) 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].[22] 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].[24] Wong *et al.* (2014) also confirmed the success of nonsurgical management of cervical disc herniations; patients substantially improved within 4–6 months, with 83% showing complete recoveries within 24–36 months. [Table 5].[25] 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].[8] Finally, in 2015, Corniola determined; "the majority of cervical disc herniations can be supported by means of (a) conservative treatment" [Table 5].[7]

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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Conflicts of interest

There are no conflicts of interest.

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