Original Study

Comparison of surgical outcomes after anterior cervical discectomy and fusion: does the intra-operative use of a microscope improve surgical outcomes

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Background: The primary aim of this study was to assess and compare the complications profile as well as long-term clinical outcomes between patients undergoing an Anterior Cervical Discectomy and Fusion (ACDF) procedure with and without the use of an intra-operative microscope.

Methods: One hundred and forty adult patients (non-microscope cohort: 81; microscope cohort: 59) undergoing ACDF at a major academic medical center were included in this study. Enrollment criteria included available demographic, surgical and clinical outcome data. All patients had prospectively collected patient-reported outcomes measures and a minimum 2-year follow-up. Patients completed the neck disability index (NDI), short-form 12 (SF-12) and visual analog pain scale (VAS) before surgery, then at 3, 6, 12, and 24 months after surgery. Clinical outcomes and complication rates were compared between both patient cohorts.

Results: Baseline characteristics were similar between both cohorts. The mean ± standard deviation duration of surgery was longer in the microscope cohort (microscope: 169±34 minutes *vs.* non-microscope: 98±42 minutes, P<0.001). There was no significant difference between cohorts in the incidence of nerve root injury (P=0.99) or incidental durotomy (P=0.32). At 3 months post-operatively, both cohorts demonstrated similar improvement in VAS-neck pain (P=0.69), NDI (P=0.86), SF-12 PCS (P=0.84) and SF-12 MCS (P=0.75). At 2-year post-operatively, both the microscope and non-microscope cohorts demonstrated similar improvement from base line in NDI (microscope: 13.52±25.77 *vs.* non-microscope: 19.51±27.47, P<0.18), SF-12 PCS (microscope: 4.15±26.39 *vs.* non-microscope: 11.98±22.96, P<0.07), SF-12 MCS (microscope: 9.47±32.38 *vs.* non-microscope: 16.19±30.44, P<0.21). Interestingly at 2 years, the change in VAS neck pain score was significantly different between cohorts (microscope: 2.22±4.00 *vs.* non-microscope: 3.69±3.61, P<0.02).

Conclusions: Our study demonstrates that the intra-operative use of a microscope does not improve overall surgery-related outcomes, nor does it lead to superior long-term outcomes in pain and functional disability, 2 years after index surgery.

Keywords: Surgical outcomes; anterior cervical discectomy and fusion (ACDF); cervical spine; intra-operative microscope; patient-reported outcomes

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Introduction

Since the advent of the anterior approach to the cervical spine, several modifications to the surgical technique including refinements made by Cloward in 1958 and Bailey-Badgley in 1960 have been described (1-5). In 1975, Hankinson and Wilson were the first to describe their experience with the use of the operating microscope for anterior cervical discectomy without fusion (5,6). The authors reported their experience with 51 patients undergoing anterior cervical discectomy without fusion and noted superior visualization of surgical anatomy, which facilitated a safer operation and more extensive decompression of neural elements (5). Whether the use of the intra-operative microscope portends a more extensive decompression with fewer intra-operative complications and superior long-term outcomes remains unknown.

The primary aim of this study was to assess and compare the complications profile as well as long-term clinical outcomes between patients undergoing an ACDF procedure with and without the use of an intra-operative microscope.

Methods

Patient selection

We queried a prospectively maintained data registry at a major academic institution. Institutional Review Board approval was obtained prior to study initiation. We included patients aged 18 years and older, (I) who presented with neck pain, radiculopathy or myelopathy; (II) underwent anterior cervical discectomy and fusion (ACDF) with or without the use of a surgical microscope; and (III) had available patient reported outcomes measures at baseline, 3-, 6-, 12-, and 24-month after surgery. Patients were excluded if they had (I) prior ACDF or (II) severe co-existent pathology that could confound the assessment of operative outcome (e.g., rheumatoid arthritis, osteoarthritis, metabolic bone disease).

Immediate postoperative complications

We assessed postoperative complications for each patient included in the study. Complications were divided into those likely or possibly associated with the surgery, including nerve root injury, durotomy, surgical site drainage or infection and reoperation. Other complications known to be associated with ACDF surgery [e.g., pulmonary embolism (PE)/deep vein thrombosis (DVT)] were also assessed.

Patient reported outcomes

Neck pain was assessed using the neck-pain visual analog scale (NP-VAS), and functional status was assessed using the neck disability index (NDI) and short-form 12 (SF-12) physical component score (PCS). The SF-12 mental component score (MCS) was used for the assessment of mental health status. These questionnaires have been validated, widely used and accepted in spine research.

Statistical analysis

We compared patient and surgical variables, pain measures and functional status between patients undergoing ACDF with and without the use of an operating microscope. Demographic variables evaluated included patient age, gender, and body mass index (BMI). Co-morbidities included hypertension, diabetes, hyperlipidemia (HLD), coronary artery disease (CAD), and myocardial infarction (MI). Surgical variables included number of vertebral levels treated, duration of surgery, and estimated blood loss (EBL).

Parametric data was expressed as means ± standard deviation (SD) and compared via the student test. Nonparametric data was expressed as median [interquartile range (IQR)] and compared via the Mann-Whitney U test. Nominal data was compared with the Chi-square test. All tests were two-sided and were statistically significant if the P value was less than 0.05.

Results

One hundred and forty patients (microscope cohort: n=59; non-microscope cohort: n=81) were enrolled in this study. We included patients 18 years and older with both clinical and radiographic indications for ACDF, and available 3-, 6-, 12-, and 24-month follow-up data. We excluded patients that had prior ACDF surgery or severe co-existent pathologies that could confound their perception of functional improvement.

There was no significant difference in age between both groups (microscope cohort: 54.50±13.29 years *vs.* non-microscope cohort: 51.62±12.9 years, P=0.20. Furthermore, there was no significant difference in BMI between both groups (microscope cohort: 27.78±6.14 kg/m^2 *vs.* non-microscope cohort: 29.60±7.66 kg/m^2, P=0.12. More men

Table 1 Comparison of demographic and comorbidity data in patients undergoing anterior cervical discectomy and fusion with and without the use of a microscope. Both cohorts of patients were similar at baseline

Patient variables	Microscope cohort (n=59)	Non-microscope cohort (n=81)	P value
Mean age (years)	54.50±13.29	51.62±12.98	0.20
Male (%)	52.54	41.97	0.21
BMI (kg/m^2)	27.78±6.14	29.60±7.66	0.12
Smoker (%)	20.33	32.09	0.11
Hypertension (%)	40.67	44.44	0.65
Diabetes (%)	10.16	12.34	0.68
HLD (%)	35.59	29.62	0.49
CAD (%)	11.86	11.11	0.89
MI (%)	5.08	2.46	0.43

Data expressed as mean ± SD or number (%). Values significant at the P<0.05 level are in bold. BMI, body mass index; HLD, hyperlipidemia; CAD, coronary artery disease; MI, myocardial infarction.

Table 2 Patient reported outcomes in neck-pain (VAS-NP), functional disability (NDI) and SF-12 PCS and SF-12 MCS after anterior cervical discectomy and fusion showed no statistically significant difference between both cohorts at 2-year follow-up

Patient variables	Microscope cohort (n=59)	Non-microscope cohort (n=81)	P value
Baseline patient reported outcomes measures (mean ± SD)			
NP-VAS	4.85±2.93	4.88±3.35	0.95
NDI	54.50±13.29	51.62±12.98	0.20
SF-12 PCS	32.94±9.51	31.72±8.50	0.56
SF-12 MCS	43.46±12.57	42.20±12.16	0.66
Three-month patient reported outcomes measures (mean ± SD)			
NP-VAS	2.88±2.92	1.75±2.71	0.30
NDI	35.33±23.17	26.58±20.51	0.32
SF-12 PCS	33.53±9.37	36.05±10.13	0.69
SF-12 MCS	46.60±3.27	48.32±11.44	0.55
Two-year patient reported outcomes measures (mean ± SD)			
NP-VAS	2.00±3.02	0.4±0.96	0.02
NDI	25.04±22.78	26.54±16.05	0.81
SF-12 PCS	44.93±11.88	37.91±8.74	0.07
SF-12 MCS	46.22±13.26	48.65±10.66	0.59

NP-VAS, neck pain visual analog pain scale; NDI, neck disability index; SF-12, short form 12; PCS, physical composite score; MCS, mental composite score .

were included in the Microscope cohort (52.54%) compared to the Non-microscope cohort (41.97%), *Table 1*. There were no co-morbidity differences in hypertension, diabetes, HLD, CAD, MI, or smoking status between both groups, *Table 1*.

Pre-operative baseline patient-reported outcome measures

At baseline, there was no significant difference in baseline functional status between both groups. The mean ± SD NP-VAS score for the Microscope and Non-microscope cohort was 4.85±2.93 and 4.88±3.35, P=0.95, respectively, *Table 2*. The pre-operative mean ± SD NDI score for the Microscope- and Non-microscope cohort was 54.50±13.29 and 51.62±12.98, P=0.20, respectively, *Table 2*. The mean ± SD SF-12 PCS score for the Microscope- and Non-microscope cohort was 32.94±9.51 and 31.72±8.50, P=0.56, respectively, *Table 2*. The mean ± SD SF-12 MCS score for the Microscope cohort and Non-microscope cohort was 43.46±12.57 and 42.20±12.16, P=0.66, respectively, *Table 2*.

Post-operative complications profile

The only significant difference between the two groups was the duration of surgery; the mean ± SD duration of surgery (minutes) for the microscope- and non-microscope cohort was 169.34±50.79 and 98.03±42.36 minutes, P=0.01, respectively, *Table 3*. The mean ± SD EBL (mL) for the microscope- and non-microscope cohort was 129.31±270.00 and 78.33±151.91 mL P=0.21, respectively, *Table 3*.

Overall, the incidence of post-operative complications was similar in both groups, *Table 3*. There was no incidental durotomy or nerve root injury in either cohort. In total, 3 patients had a surgical site infection (Microscope cohort: 3.38% *vs*. Non-microscope 1.23%, P=0.42). There were 3 patients with urinary tract infections (UTI) (Microscope cohort: 0% *vs*. Non-microscope: 3.7% P=0.08), and 2 patients who had pneumonia (microscope cohort: 1.69% *vs*. non-microscope 1.23%, P=0.82), *Table 3*. No patient had a peri-operative PE/DVT, *Table 3*.

There was no statistically significant difference between both cohorts in all patient-reported outcome metrics 3 months after ACDF with and without the use of a surgical microscope, *Table 2*. At 3 months, the mean ± SD NP-

Table 3 Cohort-specific post-operative complication rates. When compared to the microscope cohort, patients in the non-microscope cohort had a higher post-operative complication rate

Patient variables	Microscope cohort (n=59)	Non-microscope cohort (n=81)	P value
Median [IQR] # of levels fused	2 [1–2]	2 [1–3]	0.56
Duration of surgery (minutes)	169.34±50.79	98.03±42.36	0.01
EBL (mL)	129.31±270.00	78.33±151.91	0.21
Durotomy (%)	0.00	0.00	0.00
Nerve root injury (%)	0.00	0.00	0.00
PE/DVT (%)	0.00	0.00	0.00
UTI (%)	0.00	3.70	0.08
Pneumonia (%)	1.69	1.23	0.82
SSI (%)	3.38	1.23	0.42
30-day re-admission rate (%)	10.16	4.93	0.26

Values significant at the P<0.05 level are in bold. IQR, interquartile range; EBL, estimated blood loss; PE, pulmonary embolism; DVT, deep venous thrombosis; SSI, surgical site infection; UTI, urinary tract infection.

VAS for the microscope and non-microscope cohort was 2.88±2.92 and 1.75±2.71, P=0.30, respectively, *Table 2*. The mean ± SD NDI for the Microscope and Non-microscope cohort was 35.33±23.17 and 26.58±20.51 P=0.32, respectively, *Table 2*. The mean ± SD SF-12 PCS for the Microscope and Non-microscope cohort was 33.53±9.37 and 36.05±10.13, P=0.69, respectively, *Table 2*. The mean ± SD SF-12 MCS for the microscope cohort and non-microscope cohort was 46.60±3.27 and 48.32±11.44, P=0.55, respectively, *Table 2*.

There was no statistically significant difference between the two cohorts in patient-reported outcomes measures, 2 years after index surgery (*Figure 1*). The mean ± SD NDI for the Microscope and Non-microscope cohort was 25.04±22.78 and 26.54±16.05, P=0.81, respectively, *Table 2*. The mean ± SD SF-12 PCS for the Microscope and Non-microscope cohort was 44.93±11.88 and 37.91±8.74, P=0.07, respectively, *Table 2*. The mean ± SD SF-12 MCS for the Microscope and Non-microscope cohort was 46.22±13.26 and 48.65±10.66, P=0.59, respectively, *Table 2*.

Discussion

In this 2-year longitudinal cohort analysis of ACDF with and without the use of the operating microscope, we demonstrate that there are no significant differences in the complications profile or the long-term outcomes with and without the use of an intra-operative microscope. As expected, the duration of surgery was longer in the microscope compared to the non-microscope cohort.

As ACDF procedures have been shown to be a safe and clinically effective treatment, these procedures are great comparator for examining the efficacy of different surgical techniques and equipment. ACDF has been used as a gold-standard treatment for cervical radiculopathy and myelopathy (7-9). Most ACDF procedures are performed without the use of an intra-operative microscope. Cauthen *et al*. in a study of 348 patients undergoing single and multilevel ACDF's without the use of an intra-operative microscope demonstrated good outcomes in the majority of patients (10). The authors found, with a minimum of a 2-year follow-up, that 78% of the patients were satisfied with their outcomes, and 83% of the patients were able to return to work (10). Furthermore, the authors identified 2,037 patients in a literature review, from 1975 to 1996, who underwent an ACDF without the use of an intra-operative microscope and found that there was an overall fusion success rate of 92% (10). Analogous to this study, we found no differences in the complications profiles and long-term outcomes between both microscope and non-microscope cohorts.

ACDF procedures performed with the use of an operative microscope have also shown successful long-term with low complications profiles. Omidi-Kashani *et al*. in a recent study of 74 patients undergoing ACDF's with the use of an intra-operative microscope demonstrated excellent outcomes in the majority of patients (11). Under Odom's criteria, the authors found that 89.7% of patients reported functional outcomes as either good or excellent (11,12). NDI and visual analog scale (VAS) were also

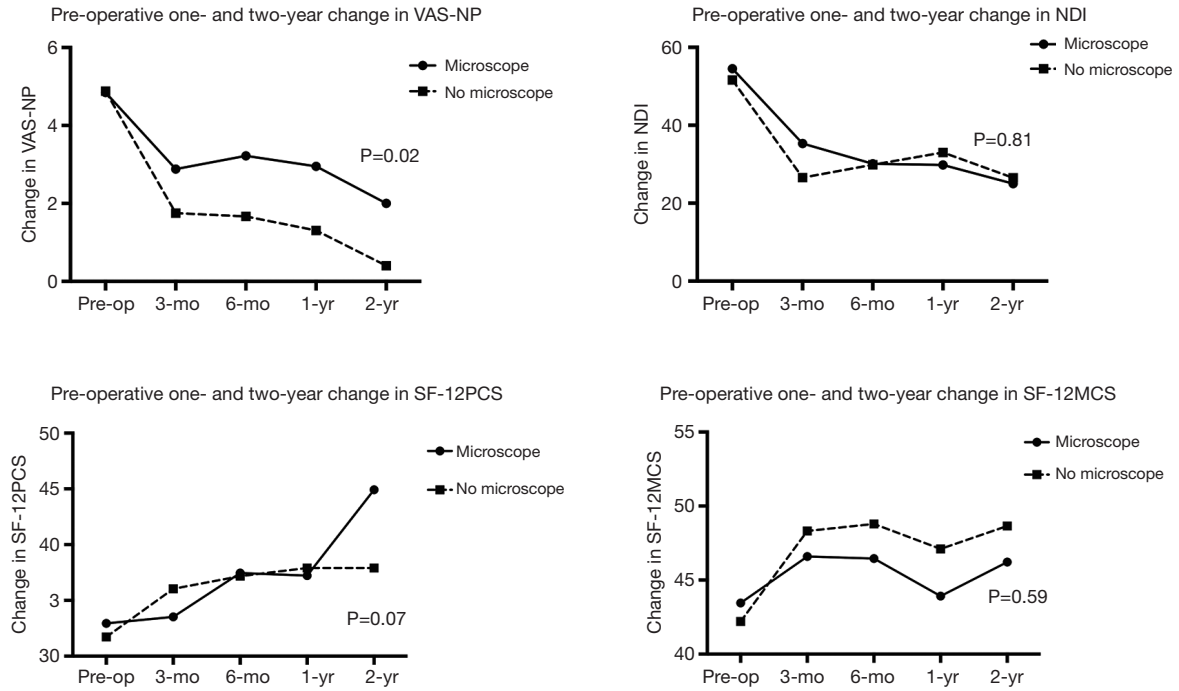

Figure 1 Patient reported outcomes over a 2-year follow up period; there was no difference between cohorts in NDI, SF-12 PCS and SF-12 MCS. There was a significant difference in VAS NP score favoring the no-microscope cohort. NP-VAS, neck pain visual analog pain scale; NDI, neck disability index; PCS, physical component score; MCS, mental component score; mo, month; yr, year.

significantly improved, 31 months after index surgery (11). Wirth *et al*. in an earlier study of 25 patients undergoing ACDF's with the use of an intra-operative microscope demonstrated successful outcomes in all of the patients (13). The authors found that 100% of the patients indicated pain improvement 2 months post-operatively (13). Furthermore, 96% of the patients returned to work by 2 months and 81% remained at work, 69 months after index surgery (13).

The duration of surgery appears to be longer with the use of an intra-operative microscope. In a recent study of 116 thyroidectomies with and without the use of an intraoperative microscope, Davidson and colleagues reported a significant increase (P<0.001) of 30 minutes in procedures with the use of an intra-operative microscope (14). The authors attributed the increased operative time to the time used to adjust the microscope for visualization of the surgical field (14).

Along with the increase in length of surgery, there is also an increase in surgical cost with the use of an intra-operative microscope. In a recent systematic review of 10 ACDF studies, Alvin colleagues observed that direct costs ranged from $5,396 to $29,898; with increased costs of surgical instruments and longer duration of surgery consistently associated with increased total cost of surgery (15). Damodaran *et al*. in a recent review suggested that one of the prime limitations of using an operating microscope for spine surgery is the expensive cost; however, the authors suggest that the cost benefit may be worth the better surgical outcomes (16).

This study has limitations, ensuing possible implications for its interpretation. While pre- and perioperative variables were prospectively recorded into the study registry at the time of surgery, these variables were retrospectively analyzed for the purposes of this study and are subject to the weaknesses of a retrospective analysis. Additionally, the duration of symptoms preoperatively could not be assessed and could presumably impact the patient-reported outcomes. Despite these limitations, this study has demonstrated that the use of an intra-operative microscope does not lead to superior outcomes.

Conclusions

The intra-operative use of a microscope enhances the visualization of surgical anatomy, however, the results of this study indicate that it does not improve overall surgery-

related outcomes, nor does it lead to superior long-term outcomes in pain and functional disability, 2 years after index surgery.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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