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Preservation of Cervical Posterior Muscle Volume and Cervical Alignment: Comparison Between three types of modified muscle-sparing laminoplasty and Conventional Open-Door laminoplasty for multilevel degenerative cervical myelopathy

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Backgrounds: Several modified laminoplasties (LP) have been developed to preserve the posterior muscle-ligament complex and prevent postoperative axial symptoms and malalignment in treatment of multilevel degenerative cervical myelopathy (MDCM). The postoperative change of cervical alignment and posterior muscle volume (PMV) following these procedures remains controversial.

Research question: This study aimed to compare the post-LP change in PMV and cervical alignment of conventional LP and three types of muscle-sparing LPs, namely unilateral muscle-preservation laminoplasty (UL), spinous-process-splitting double-door laminoplasty (DL) and intermuscular "raising roof" laminoplasty (RL).

Methods: Consecutive MDCM patients who underwent LP, DL, UL or RL between February 2022 and May 2022 from single center were enrolled. The baseline data, surgical characteristics were collected. The preoperative and postoperative PMV were semiautomatically segmented and evaluated by ITK-SNAP and the cervical alignment of patients were measured. The PMV loss ratio was calculated by the change of PMV divided by preoperative PMV.

Results: A total of 79 MDCM patients were included in this study (LP: 20, DL: 20, UL:23, RL:16). No significant differences were observed in the preoperative demographics and surgical characteristics. The preoperative C2-7 Cobb angles and PMV of four groups were comparable. At 1-year follow-up, all four groups showed favorable and comparable JOARR and significant loss in PMV. The RL group showed least PMV loss ratio and least loss of C2-7 Cobb angle at neutral position and at extension. Multivariate regression revealed that the loss in cervical alignment was associated with the PMV loss ratio.

Discussion: The RL procedure demonstrated better efficacy in PMV and cervical alignment preservation compared to conventional LP in treating MDCM. The loss of cervical lordosis at neutral and at extension position was associated with the PMV loss ratio.

Fig. 1

Figure 1. Surgical schematic diagrams of four types of modified laminoplasties.⁴²

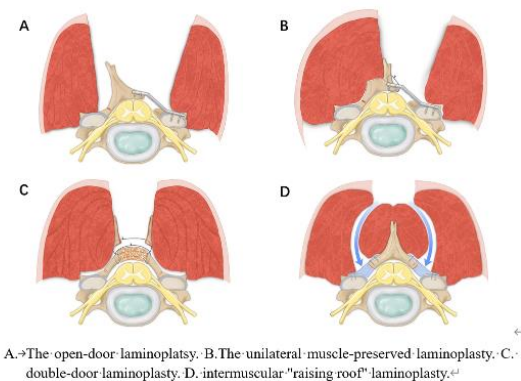
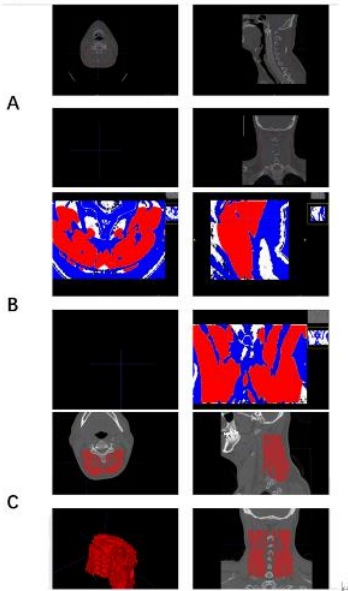


Fig. 2

Figure 2. The semiautomatic segmentation and measurement methods of PMV.⁴³



A: The determination of region of interest (ROI) in posterior muscle volume evaluation.⁴³

B: The semiautomatic segmentation by threshold and evolution algorithms using ITK-SNAP software.⁴³

C: The results of segmentation was manually correcting and the PMV was measured.⁴³

Fig. 3

Table 1. Demographic, clinical and surgical characteristics of the four groups^{a)}

Variables ^{b)}	LP (n=20) ^{b)}	DL (n=20) ^{b)}	UL (n=23) ^{b)}	RL (n=16) ^{b)}	P value ^{c)}
Age ^{c)}	56.8±7.2 ^{c)}	58.2±9.7 ^{c)}	58.4±10.3 ^{c)}	59.5±6.2 ^{c)}	0.753 ^{c)}
Male sex ^{c)}	15(75%) ^{c)}	12(60%) ^{c)}	19(82.6%) ^{c)}	12(75%) ^{c)}	0.415 ^{c)}
Diabetes Mellitus ^{c)}	3(15%) ^{c)}	1(5%) ^{c)}	6(26.1%) ^{c)}	2(12.5%) ^{c)}	0.287 ^{c)}
High Blood Pressure ^{c)}	8(40%) ^{c)}	4(20%) ^{c)}	9(39.1%) ^{c)}	3(18.8%) ^{c)}	0.295 ^{c)}
Axial Symptoms ^{c)}	13(65%) ^{c)}	8(40%) ^{c)}	11(47.8%) ^{c)}	9(56.3%) ^{c)}	0.432 ^{c)}
pre-JOA ^{c)}	12.7±3.16 ^{c)}	13.35±2.10 ^{c)}	12.70±2.66 ^{c)}	13.41±1.49 ^{c)}	0.846 ^{c)}
post-JOA ^{c)}	15.95±1.04 ^{c)}	16.10±0.47 ^{c)}	15.74±0.93 ^{c)}	16.10±0.83 ^{c)}	0.363 ^{c)}
JOARR ^{c)}	73.69±23.53% ^{c)}	69.67%±15.02% ^{c)}	68.03%±18.70% ^{c)}	73.75%±26.02% ^{c)}	0.443 ^{c)}
segments ^{c)}	5.2±0.5 ^{c)}	5.0±0.7 ^{c)}	5.0±0.6 ^{c)}	4.9±0.3 ^{c)}	0.466 ^{c)}
surgery duration ^{c)}	94±16.47 ^{c)}	98.1±20.6 ^{c)}	103.6±11.5 ^{c)}	113.8±20.3 ^{c)}	0.177 ^{c)}
blood loss ^{c)}	193.5±79.1 ^{c)}	144.5±118.9 ^{c)}	188.7±228.4 ^{c)}	231.3±117.8 ^{c)}	0.002 ^{c)}

Table 2. The postoperative and postoperative change in cervical alignment and CPM volume^{a)}

Variable ^{b)}	LP (n=20) ^{b)}	DL (n=20) ^{b)}	UL (n=23) ^{b)}	RL (n=16) ^{b)}	P value ^{c)}
Preoperative CT ^{c)}	11.59±8.80 ^{c)}	9.54±11.18 ^{c)}	11.05±11.32 ^{c)}	10.75±10.90 ^{c)}	0.962 ^{c)}
Preoperative CT-T ^{c)}	23.33±10.33 ^{c)}	21.18±12.17 ^{c)}	20.97±9.92 ^{c)}	18.50±12.88 ^{c)}	0.807 ^{c)}
Preoperative CL-F ^{c)}	-10.23±7.09 ^{c)}	-12.73±11.24 ^{c)}	-13.02±10.39 ^{c)}	-18.53±13.05 ^{c)}	0.532 ^{c)}
Preoperative ROM ^{c)}	39.45±10.65 ^{c)}	34.9±15.41 ^{c)}	34.02±14.27 ^{c)}	37.11±15.09 ^{c)}	0.701 ^{c)}
Postoperative CT ^{c)}	8.95±9.84 ^{c)}	10.72±9.87 ^{c)}	6.02±9.45 ^{c)}	10.77±12.37 ^{c)}	0.370 ^{c)}
Postoperative CT-T ^{c)}	17.71±9.12 ^{c)}	20.60±10.23 ^{c)}	15.09±9.52 ^{c)}	18.43±12.63 ^{c)}	0.296 ^{c)}
Postoperative CL-F ^{c)}	-5.30±9.69 ^{c)}	-6.76±9.16 ^{c)}	-7.02±11.49 ^{c)}	-8.74±13.96 ^{c)}	0.931 ^{c)}
Post ROM ^{c)}	23.51±9.56 ^{c)}	27.45±8.58 ^{c)}	22.11±11.32 ^{c)}	27.17±11.04 ^{c)}	0.139 ^{c)}
Change in CT ^{c)}	-2.64±7.83 ^{c)}	1.18±6.82 ^{c)}	-5.06±6.42 ^{c)}	0.02±6.96 ^{c)}	0.031 ^{c)}
Change in CL-E ^{c)}	-5.52±6.20 ^{c)}	-0.49±7.85 ^{c)}	-5.88±8.18 ^{c)}	-0.16±9.35 ^{c)}	0.025 ^{c)}
Change in CL-F ^{c)}	10.43±8.70 ^{c)}	6.97±13.03 ^{c)}	6.03±9.35 ^{c)}	9.79±10.20 ^{c)}	0.668 ^{c)}
Change in ROM ^{c)}	-15.95±10.75 ^{c)}	-7.46±16.23 ^{c)}	-11.91±12.79 ^{c)}	-9.94±14.91 ^{c)}	0.343 ^{c)}
Pre PMV *10 ³ mm ³ ^{c)}	2.726±0.79 ^{c)}	2.607±0.752 ^{c)}	2.808±0.724 ^{c)}	2.686±0.674 ^{c)}	0.802 ^{c)}
Post PMV *10 ³ mm ³ ^{c)}	2.430±0.68 ^{c)}	2.355±0.621 ^{c)}	2.416±0.667 ^{c)}	2.595±0.667 ^{c)}	0.652 ^{c)}
Loss in PMV *10 ³ mm ³ ^{c)}	0.296±0.37 ^{c)}	0.251±0.347 ^{c)}	0.393±0.313 ^{c)}	0.091±0.272 ^{c)}	0.027 ^{c)}
PMV loss ratio ^{c)}	10.02%±12.92% ^{c)}	8.69%±9.61% ^{c)}	13.69%±10.40% ^{c)}	3.12%±10.92% ^{c)}	0.037 ^{c)}

Abbreviations: CL: cervical lordosis, CL-E: cervical lordosis at extension, CL-F: cervical

lordosis at flexion, PMV: posterior muscle volume, ROM: range of motion. The change was calculated by the posterior measurements minus preoperative measurements.^{c)}