临床论著

颈后路单侧显露选择性通道辅助下椎管扩大椎板成形术治疗多节段颈椎退行性疾病的疗效观察

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【摘要】目的:评价颈后路单侧显露选择性通道辅助下椎管扩大椎板成形术(selective channel-assisted laminoplasty,SCA-LP)治疗多节段颈椎行性疾病的安全性与有效性,并对比 3 种颈椎后路单开门椎管扩大椎板成形术(laminoplasty,LP)的临床疗效。**方法**:回顾性分析 2020 年 3 月~2021 年 7 月共 114 例行颈后路 LP 的患者资料,其中男 62 例、女 52 例,年龄 58.27±7.36 岁。其中多节段脊髓型颈椎病 52 例、颈椎管狭窄症 25 例、颈椎后纵韧带骨化症 37 例。39 例患者接受了颈后路单侧显露 SCA-LP,33 例患者接受了颈后路单侧显露完全保留对侧椎旁肌的椎管扩大椎板成形术(muscle-preserved laminoplasty,MP-LP),42 例患者接受了常规的颈后路单开门 LP。随访 12~28 个月(18.46±5.75 个月)。比较三组患者的年龄、性别、体重指数(body mass index,BMI)。记录并比较三组的手术时间、术中出血量、术后引流量及平均住院日。于术前、术后即刻、术后 2 个月、术后 12 个月及末次随访时采用疼痛视觉模拟量表(visual analog scale,VAS)评分评估颈部和上肢疼痛程度,颈椎功能障碍指数(neck disability index,NDI)评价患者颈椎功能,日本骨科学会(Japanese Orthopedic Association,JOA)评分评估神经功能状况。在术前、术后即刻、术后 2 个月、术后 12 个月及末次随访时的颈椎侧位 X 线片上测量 C2-C7 Cobb 角、CT 横断面上测量骨性椎管面积,比较三种手术方法对 C2-C7 Cobb 角的影响及椎管面积的增加程度(比较每个节段的增加程度及每例患者的平均增加程度)。**结果**:三组患者的年龄、性别、BMI 差异无统计学意义(P>0.05)。所有患者均顺利完成手术,术后均未发生神经损伤、感染等并发症。手术时间及平均住院日 MP-LP 组均最短、SCA-LP 组次之、LP 组最长,术中出血量及术后引流量 MP-LP 组均最少、SCA-LP 组次之、LP 组最多,三组间的差异均有统计学意义(P<0.05)。三组患者术后各时间点 NDI 及 JOA 评分均较术前有明显改善(P<0.05),术前、术后即刻、术后 2 个月、术后 12 个月及末次随访时的 NDI 及 JOA 评分三组间均无统计学差异(P>0.05)。LP 组中,术后即刻的颈痛 VAS 评分要高于术前,术后 12 个月及末次随访时低于术前,差异均有统计学意义(P<0.05);术后 2 个月的颈痛 VAS 评分与术前比较无统计学差异(P>0.05)。SCA-LP 组、MP-LP 组术后即刻的颈痛 VAS 评分与术前的差异均无统计学意义(P>0.05),术后 2 个月、12 个月及末次随访均显著低于术前(P<0.05)。术后即刻及术后 2 个月随访,SCA-LP 组、MP-LP 组的颈痛 VAS 评分均显著低于 LP 组(P<0.05);术后 12 个月及末次随访三组的颈痛 VAS 评分差异无统计学意义(P>0.05)。三组术后即刻的 C2-C7 Cobb 角均较术前无统计学差异(P>0.05),LP 组术后 2 个月、12 个月及末次随访的 C2-C7 Cobb 角均显著小于术前(P<0.05),SCA-LP 组、MP-LP 组术后 2 个月的 C2-C7 Cobb 角均与术前无统计学差异(P>0.05),SCA-LP 组、MP-LP 组术后 12 个月及末次随访的 C2-C7 Cobb 角均显著小于术前(P<0.05)。三组间术前及术后即刻 C2-C7 Cobb 角差异无统计学意义(P>0.05),术后 2 个月、12 个月及末次随访的 C2-C7 Cobb 角 SCA-LP 组、MP-LP 组均大于 LP 组(P<0.05)。三组间术后即刻、2 个月、12 个月及末次随访的平均椎管面积增加百分比差异无统计学意义(P>0.05)。SCA-LP 组中所有患者的 C7(100%)、12 例患者的 C6(30.77%)、6 例患者的 C3(15.38%)需要通道下制作铰链。术后即刻、2 个月、12 个月及末次随访 SCA-LP 组和 LP 组患者 C7 的椎管面积增加程度均优于 MP-LP 组(P<0.05);三组间 C3~C6 椎管面积增加程度的差异无统计学意义(P>0.05)。**结论**:与常规的颈后路单开门 LP 相比,两种改良术式均能有效减少铰链侧肌肉韧带的损伤,术后加速康复,减少术后早期轴性颈痛的发生率。与 MP-LP 相比,SCA-LP 能更有效地增加手术节段的椎管面积。

【关键词】椎管扩大椎板成形术;选择性通道辅助;单侧显露;疗效

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doi:10.3969/j.issn.1004-406X.2023.02.02
中图分类号:R681.5,R687.3 文献标识码:A 文章编号:1004-406X(2023)-02-0104-11

The effect of posterior unilateral exposure and selective channel-assisted laminoplasty in the treatment of multilevel degenerative cervical spondylosis/SHEN Xiaolong, WEI Leixin, XU Chen, et al//Chinese Journal of Spine and Spinal Cord, 2023, 33(2): 104-114

【**Abstract**】 **Objectives:** To evaluate the clinical safety and effectiveness of posterior unilateral exposure and selective channel-assisted laminoplasty(SCA-LP) in the treatment of multi-level degenerative cervical spondylosis and to compare the clinical outcomes of three types of posterior open-door laminoplasty. **Methods:** A total of 114 patients underwent posterior laminoplasty(LP) from March 2020 to July 2021 were analyzed retrospectively, including 62 males and 52 females, with an average age of 58.27±7.36 years. Among them, there were 52 cases of multilevel cervical spondylotic myelopathy(MCSM), 25 cases of cervical canal stenosis(CCS), and 37 cases of ossification of posterior longitudinal ligament(OPLL). 39 patients received unilateral exposure and SCA-LP (SCA-LP group), 33 patients received unilateral exposure and contralateral paravertebral musle-preserved(MP) LP(MP-LP group) and 42 patients were treated with traditional open-door LP(LP group). The patients were followed up for 12-28 months(18.46±5.75 months). Patient characteristics such as age, gender and body mass index(BMI) were compared between groups. Surgical parameters such as the operative time, blood loss, amount of post-operative drainage, and average length of hospital stay were collected and compared. At before operation, immediately after operation, 2 and 12 months postoperatively, and final follow-up, clnical parameters such as visual analog scale(VAS) assessing neck and arm pains, neck disability index(NDI) assessing cervical function and Japanese Orthopedic Association (JOA) scores assessing neurological status were recorded and compared between groups respectively; and C2-C7 Cobb angle and the cross-sectional area of spinal canal were measured on lateral X-ray films of cervical spine to compare the effects of the three surgical methods on C2-C7 Cobb angle and the increase of spinal canal area (the increase of each segment and the average increase of each patient). **Results:** There were no significant differences in age, gender and BMI between the three groups(P>0.05). All patients underwent the operation uneventfully, and no serious complications such as nerve injury or infection occurred. MP-LP group was the shortest and LP group was the longest in operative time and average length of hospital stay, and MP-LP group was the smallest and LP group was the biggest in the volume of blood loss and postoperative drainage, with signicant differences (P<0.05). The postoperative NDI and JOA scores of the three groups of patients were significantly improved compared with those before operation(P<0.05), and no significant differences were found in NDI and JOA scores between the three groups before operation, immediately after operation, 2 and 12 months after operation and at the last follow-up(P>0.05). In the LP group, the VAS score of neck pain immediately after operation was higher than that before operation, and at 12 months after operation and final follow-up it was lower than that before operation, and the differences were statistically significant (P<0.05); and no difference was found between 2 months after operation and before operation(P>0.05). In the SCA-LP group and MP-LP group, the VAS score of neck pain immediately after operation was not statistically different from that before operation(P>0.05) and it was significantly lower at 2 months, 12 months after operation and the last follow-up than that before operation(P<0.05). The VAS score of neck pain in the SCA-LP group and MP-LP group was lower than that in LP group immediately after operation and at 2-month follow-up(P<0.05), and there was no significant difference between the three groups at 12 months after operation and the last follow-up(P>0.05). The C2-C7 Cobb angle immediately after operation in the three groups had no significant differences than before operation (P> 0.05); In LP group, it was smaller at 2 and 12 months after operation and the last follow-up than before operation(P<0.05). In the SCA-LP group and MP-LP group, at 2 months after operation it was not significantly different from that before operation (P>0.05), and it was significantlly lower at 12 months after operation and the last follow-up than that before operation (P<0.05). There was no significant difference between the three groups in the differences of C2-C7 Cobb angle between before operation and immediately after operation (P> 0.05). The C2-C7 Cobb angle in the SCA-LP group and MP-LP group was significantly bigger than that in

LP group at 2 and 12 months after operation and the last follow-up (P<0.05). There was no significant difference in the increased percentage of average area of spinal canal between the three groups immediately after operation, 2 and 12 months after operation and at the last follow-up(P>0.05). In the SCA-LP group, C7 (100%) of all the patients, C6(30.77%) of 12 patients, and C3(15.38%) of 6 patients needed to make hinge under the channel. The increase of C7 spinal canal area in the SCA-LP group and LP group was larger than that in MP-LP group immediately after operation, 2 and 12 months after operation and the last follow-up(P< 0.05); There was no significant difference in the increase of C3-C6 spinal canal area between the three groups(P>0.05). **Conclusions:** Comparing with LP, the two improved surgical methods can effectively reduce the injury of muscles and ligaments on the hinge side, enhance recovery after surgery, lower the incidence of early postoperative axial neck pain. SCA-LP can increase the area of the spinal canal of operative segment more effectively than MP-LP.

【Key words】 Laminoplasty; Selective channel-assisted; Unilateral exposure; Effect

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颈后路单开门椎管扩大椎板成形术已广泛应用于治疗发育性颈椎管狭窄、多节段脊髓型颈椎病及后纵韧带骨化症的患者[1,2]。然而,常规的颈后路单开门椎管扩大椎板成形术需要广泛剥离两侧椎旁肌肉和韧带,术后存在颈部肌肉萎缩、颈部僵硬、轴性疼痛、颈椎曲度丢失甚至出现后凸畸形等诸多并发症[3-6]。为了减少对后方肌肉韧带结构的损伤,我们的前期研究报道了颈后路单侧显露完全保留对侧椎旁肌的椎管扩大椎板成形术(muscle-preserved laminoplasty,MP-LP)[7],MP-LP 可以完全保留对侧肌肉韧带,手术创伤小,患者恢复快,但是常遇到 C7、C6 椎板开门阻力较大,部分患者开门不足的情况。为了解决这一问题,我们在 MP-LP 开门不足的节段采用直接穿刺的方法置入可扩张通道,通道下制作铰链,再进行单开门椎管扩大椎板成形术,即颈后路单侧显露选择性通道辅助下椎管扩大椎板成形术(selective channel-assisted laminoplasty,SCA-LP)。为了不影响开门效果,并最大程度地保留对侧肌肉韧带的完整性,我们尝试采用 SCA-LP 技术进行椎管扩大椎板成形术,本研究旨在探讨该技术在减少出血、改善术后颈痛及扩大椎管面积等方面的临床效果。

1 资料与方法

1.1 临床资料

回顾性分析 2020 年 3 月~2021 年 7 月在我科行手术治疗的多节段颈椎退行性疾病患者的临床资料。纳入标准:①因多节段脊髓型颈椎病(multilevel cervical spondylotic myelopathy,MC-SM)、颈椎管狭窄症(cervical canal stenosis,CCS)及颈椎后纵韧带骨化症(ossification of posterior longitudinal ligament,OPLL)而接受颈后路椎管扩大椎板成形术的患者;②SCA-LP、MP-LP 或常规颈后路单开门椎管扩大椎板成形术(laminoplasty,LP),手术节段 C3~C7;③患者年龄 30~80 岁。排除标准:①需要辅助侧块螺钉固定者;②严重骨质疏松;③强直性脊柱炎等风湿类疾病;④颈椎畸形、外伤、感染、肿瘤、颈后路手术等病史。记录患者的年龄、性别、体重指数(body mass index,BMI)、入院诊断等一般信息。

最终获得随访的 114 例患者纳入研究。其中 39 例患者接受了颈后路单侧显露 SCA-LP,纳入 SCA-LP 组;33 例患者接受了颈后路单侧显露完全保留对侧椎旁肌的 MP-LP,纳入 MP-LP 组;42 例患者采用常规单开门 LP,纳入 LP 组。三组患者的年龄、性别、BMI 及入院诊断均无明显差异(P>0.05,表 1),三组数据具有可比性。

1.2 手术方法

1.2.1 SCA-LP 组 患者全身麻醉后取俯卧位,取颈后正中切口,切开皮肤长约 10cm,显露 C3~C7 皮下筋膜,手指触摸棘突分叉处,电刀沿棘突左侧骨膜下剥离,显露 C3~C7 椎板左侧及侧块内缘(图 1a),磨钻磨至内层骨皮质,开门侧用 2mm 枪钳咬除剩余骨质,使之完全离断。首先,将圆头骨膜剥离器小心伸入 C6 椎板骨槽内,小心旋转撬拨椎板,如果椎板骨槽宽度≥8mm,对侧可不做铰链。如果开门宽度<8mm,于 C6 棘突右上 10mm

处，经椎旁肌直接穿刺置入可扩张通道（自主研发设计，两扩张叶片远端宽 5mm、近端宽 8mm，图 1b），通道可向头端、尾端倾斜移动。根据开门侧的预估深度，用 3mm 磨钻头开槽制作铰链，完毕后取出通道。于 C7 棘突右上 10mm 处，经椎旁肌直接穿刺置入可扩张通道，同法制作铰链（图 1c）。随后，术者右手用圆头骨膜剥离器插入 C3 椎板的骨槽间隙，轻度旋转骨膜剥离器，使开门间隙轻度扩大，术者左手拿椎板夹持器，小心将椎板夹持器的卡口放入开门侧椎板最深面，另一卡口放置于棘突末端骨面，收紧椎板夹持器后交于一助，一助双手握持。术者双手旋转骨膜剥离器，进一步旋转撬拨椎板，此时一助协同轻轻地旋转椎板夹持器，以防止椎板回弹。如果能听到清脆的骨折声，说明对侧椎板已经断裂，提示开门已经足够，此时可以置入 ARCH 钛板（强生，美国）。如果椎板没有骨折，但开门宽度超度 8mm（可提供的最小开门宽度试模为 8mm，用 8mm 的试模直接测量开门宽度是否足够），开门宽度基本足够，此时也可置入 ARCH 钛板。相同方法处理 C4~C7 椎板。若术中发现开门不足的节段，于对侧置入通道，制作铰链。手术结束后，铰链侧肌肉韧带基本完好（图 1d）。所有患者的 C7（100%）、12 例患者的 C6（30.77%）、6 例患者的 C3（15.38%）需要通道下制作铰链。常规生理盐水冲洗，放置负压引流管后关闭切口，术后 24~48h 拔除引流管，术后第 2 天鼓励患者佩戴颈托后下床活动。

1.2.2 MP-LP 组 麻醉方法、患者体位、开门侧显露同前（图 2a），制作开门骨槽（图 2b），用椎板夹持器夹持椎板，圆头骨膜剥离器插入开门间隙，配合椎板夹持器，一同旋转开门（图 2c），C3~C7 逐个开门[7]（图 2d），余处理同 SCA-LP 组。

1.2.3 LP 组 麻醉方法、患者体位同前，取颈后正中切口，切开皮肤长约 10cm，显露 C3~C7 皮下筋膜，经棘突两侧骨膜下电刀分离肌肉，显露 C3~C7 椎板及侧块内缘。在 C3~C7 椎板右侧与侧块

表 1 三组患者的一般资料比较

Table 1 Comparison of general data between the three groups

	SCA-LP 组（*n*=39）Group SCA-LP	MP-LP 组（*n*=33）Group MP-LP	LP组（*n*=42）Group LP
性别（*n*）Gender			
男 Male	21	18	23
女 Female	18	15	19
年龄（岁）Age	58.36±7.23	59.73±7.81	56.15±8.52
BMI（kg/m^2）	26.25±3.88	25.06±3.64	25.96±4.25
诊断 Diagnosis			
MCSM	18	15	19
CCS	9	7	9
颈椎 OPLL Cervical OPLL	12	11	14

注：MCSM，多节段脊髓型颈椎病；CCS，颈椎管狭窄症；OPLL，后纵韧带骨化症

Note: MCSM, multilevel cervical spondylotic myelopathy; CCS, cervical canal stenosis; OPLL, ossification posterior longitudinal ligament

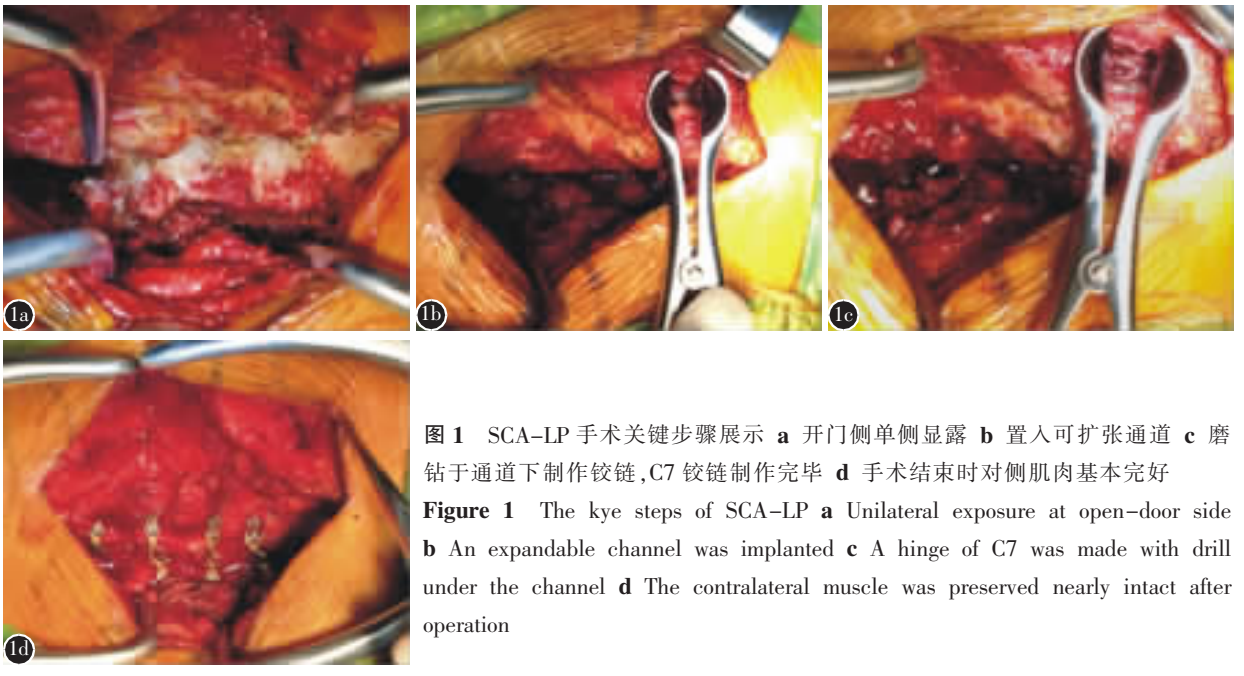

图 1 SCA-LP 手术关键步骤展示 **a** 开门侧单侧显露 **b** 置入可扩张通道 **c** 磨钻于通道下制作铰链，C7 铰链制作完毕 **d** 手术结束时对侧肌肉基本完好

Figure 1 The kye steps of SCA-LP **a** Unilateral exposure at open-door side **b** An expandable channel was implanted **c** A hinge of C7 was made with drill under the channel **d** The contralateral muscle was preserved nearly intact after operation

交界处磨钻开槽制作铰链，椎板左侧与侧块交界处开槽后，用椎板夹持器夹持椎板并旋转，逐个掀开开门，使用 ARCH 钛板（强生，美国）固定于开门侧。常规生理盐水冲洗，放置负压引流管后关闭切口，术后 48h 拔除引流管，术后第 2 天鼓励患者佩戴颈托后下床活动。

1.3 临床功能评价

记录三组患者手术时间、术中出血量、术后引流量、住院时间等指标及并发症发生情况。于术前、术后即刻、术后 2 个月、术后 12 个月、末次随访时采用疼痛视觉模拟量表（visual analog scale，VAS）评分评价患者的颈部及上肢疼痛程度，特别是术后颈部的轴性痛；采用颈椎功能障碍指数（neck disability index，NDI）评价患者颈椎功能；采用日本骨科学会（Japanese Orthopedic Association，JOA）评分评价神经功能状况。对比患者术前术后颈痛及上肢痛 VAS 评分、NDI 及 JOA 评分。

1.4 影像学评价

于术前、术后即刻、术后 2 个月、12 个月及末次随访时，在患者颈椎侧位 X 线片上采用两线 Cobb 法测量 C2–C7 Cobb 角；在患者 CT 横断面上测量原始骨性椎管面积，与术前的椎管面积做比较，计算手术后椎管面积增加百分比：（术后椎管面积–术前椎管面积）/术前椎管面积。比较组内所有患者手术节段的平均增加程度及组间每个节段的增加程度。为了减少测量误差，所有测量由 2 名高年资主治医生分别进行测量，最终测量结果取平均值。每个患者的手术节段椎管横截面积取平均值。

1.5 统计学处理

使用 SPSS 18.0 统计软件包进行统计分析，计量资料采用（均数±标准差）表示。根据三组定量资料是否满足正态分布及方差齐性情况，采用单因素方差分（One–way ANOVA）或 Kruskal–Wallis 秩和检验比较各组的整体差异是否具有统计学意义，如果组间差异有统计学意义，采用 Bonferroni 法进行两两比较，组内数据比较采用重复测量方差分析，以 $P<0.05$ 为差异有统计学意义。

2 结果

2.1 一般情况

所有患者均顺利完成手术，术后无患者出现明显神经损伤、感染等并发症。三组手术时间、术中出血量、术后引流量及平均住院日的差异均有统计学意义（$P<0.05$，表 2），手术时间及平均住院日 MP–LP 组均最短，SCA–LP 组次之，LP 组最长；术中出血量及术后引流量 MP–LP 组均最少，SCA–LP 组次之，LP 组最多。患者随访 12~28 个月，平均 18.46±5.75 个月。

2.2 临床结果

三组患者各时间点的 VAS 评分、NDI 及 JOA

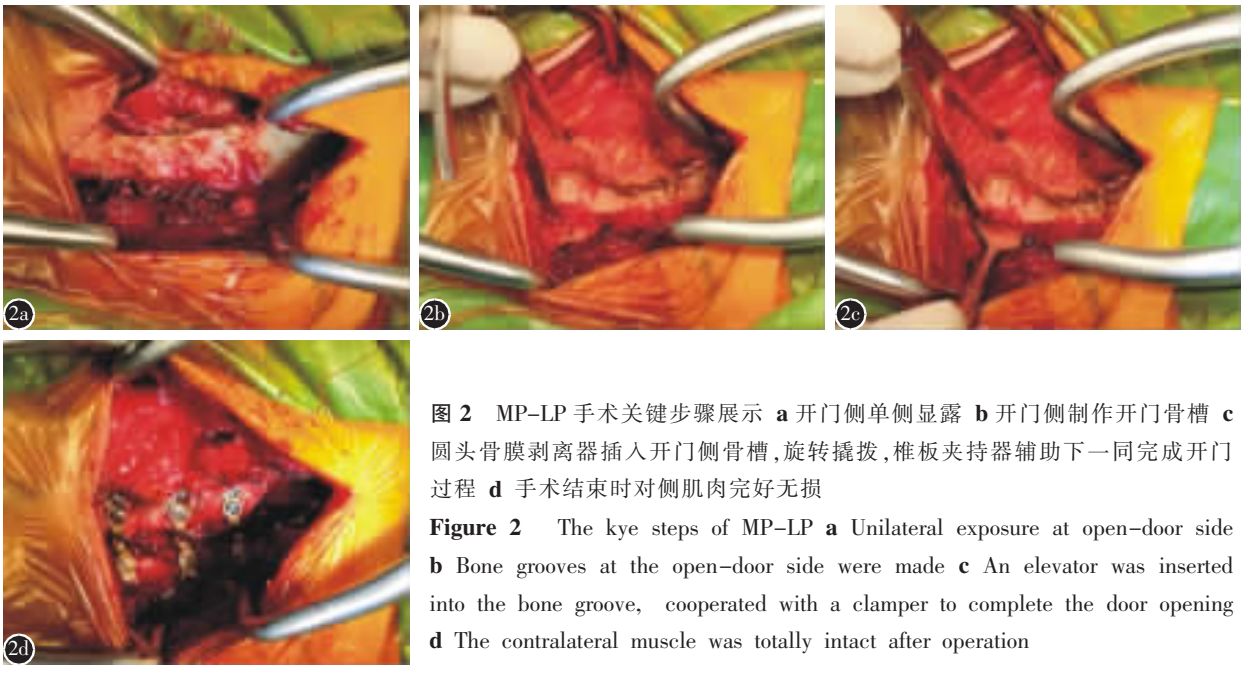

图 2 MP–LP 手术关键步骤展示 **a** 开门侧单侧显露 **b** 开门侧制作开门骨槽 **c** 圆头骨膜剥离器插入开门侧骨槽，旋转撬拨，椎板夹持器辅助下一同完成开门过程 **d** 手术结束时对侧肌肉完好无损

Figure 2 The kye steps of MP–LP **a** Unilateral exposure at open–door side **b** Bone grooves at the open–door side were made **c** An elevator was inserted into the bone groove, cooperated with a clamper to complete the door opening **d** The contralateral muscle was totally intact after operation

评分结果见表 3。三组间术前 VAS 评分、NDI 及 JOA 评分的差异均无统计学意义(P>0.05)。三组患者术后 NDI 及 JOA 评分均较术前有明显改善(P<0.05),三组间于术前、术后即刻、术后 2 个月、术后 12 个月及末次随访 NDI 及 JOA 的差异均无统计学意义(P>0.05)。LP 组中,术后即刻的颈痛 VAS 评分高于术前,术后 12 个月及末次随访低于术前,差异均有统计学意义(P<0.05);术后 2 个月与术前比较无统计学差异(P>0.05)。SCA-LP 组、MP-LP 组术后即刻的颈痛 VAS 评分与术前

表 2 三组患者的手术相关参数比较

Table 2 Comparison of operation related parameters

	手术时间(min) Operative time	术中出血量(ml) Intraoperative blood loss	术后引流量(ml) Postoperative drainage volume	住院时间(天) Hospital stay(d)
LP组(n=42) Group LP	93.68±19.37	191.55±35.59	237.51±41.72	5.93±1.36
MP-LP 组(n=33) Group MP-LP	76.23±19.56①	99.85±39.47①	121.23±29.83①	4.53±1.44①
SCA-LP 组(n=39) Group SCA-LP	85.86±18.45①②	126.94±21.62①②	140.84±30.44①②	4.62±1.34①

注:①与 LP 组比较 P<0.05;②与 MP-LP 组比较 P<0.05

Note: ①Compared with LP group, P<0.05; ②Compared with MP-LP group, P<0.05

表 3 三组患者 VAS、NDI 及 JOA 评分比较 ($\bar{x}\pm s$)

Table 3 Comparison of VAS, NDI and JOA scores between the three groups

	术前 Pre-OP	术后即刻 Immediately after operation	术后 2 个月 Po-2m	术后 12 个月 Po-12m	末次随访 Final follow-up
颈痛 VAS(分) VAS score of neck pain					
LP 组 Group LP	3.49±1.45	4.43±1.52①	3.34±1.18	1.62±1.07①	1.48±0.68①
MP-LP 组 Group MP-LP	3.44±1.42	3.36±1.40②	1.49±0.74①②	1.53±0.71①	1.45±0.62①
SCA-LP 组 Group SCA-LP	3.54±1.15	3.34±1.44②	1.58±0.69①②	1.50±0.67①	1.36±0.55①
上肢痛 VAS(分) VAS score of arm pain					
LP 组 Group LP	2.71±1.38	1.66±0.85①	1.42±0.53①	1.41±0.51①	1.46±0.46①
MP-LP 组 Group MP-LP	2.77±1.35	1.71±0.78①	1.37±0.49①	1.35±0.47①	1.40±0.42①
SCA-LP 组 Group SCA-LP	2.64±1.43	1.59±0.76①	1.35±0.44①	1.33±0.45①	1.41±0.40①
NDI(%)					
LP 组 Group LP	46.24±8.36	29.78±6.24①	24.16±3.73①	22.43±3.83①	18.57±3.25①
MP-LP 组 Group MP-LP	46.72±8.57	27.08±6.17①	24.03±4.04①	21.83±3.92①	18.72±3.31①
SCA-LP 组 Group SCA-LP	47.49±7.71	28.36±5.44①	21.66±3.68①	21.48±3.58①	17.77±3.16①
JOA评分(分) JOA score					
LP 组 Group LP	10.28±2.45	12.87±2.76①	14.26±2.77①	14.31±2.76①	14.25±2.70①
MP-LP 组 Group MP-LP	10.43±2.28	12.94±2.81①	14.13±2.83①	14.27±2.87①	14.36±2.67①
SCA-LP 组 Group SCA-LP	10.76±2.52	13.36±2.68①	14.28±3.06①	14.44±2.74①	14.47±2.59①

注:①与同组术前比较 P<0.05;②与 LP 组比较 P<0.05

Note: ①Compared with preoperation, P<0.05; ②Compared with LP group, P<0.05

无统计学差异(*P*>0.05),术后 2 个月、12 个月及末次随访均显著低于术前(*P*<0.05)。术后即刻及术后 2 个月随访,SCA-LP 组、MP-LP 组的颈痛 VAS 评分均显著低于 LP 组(*P*<0.05);术后 12 个月及末次随访,三组的颈痛 VAS 评分差异均无统计学意义(*P*>0.05)。

2.3 影像学结果

三组患者术前、术后各时间点的 C2-C7 Cobb 角及术后各时间点的平均椎管面积增加百分比见表 4。三组术后即刻的 C2-C7 Cobb 角均较术前无统计学差异 (*P*>0.05),LP 组术后 2 个月、12 个月及末次随访的 C2-C7 Cobb 角均明显小于术前 (*P*<0.05);SCA-LP 组、MP-LP 组术后 2 个月的 C2-C7 Cobb 角均与术前比较无统计学差异(*P*>0.05),术后 12 个月及末次随访均明显小于术前 (*P*<0.05)。三组间术前及术后即刻 C2-C7 Cobb 角差异无统计学意义 (*P*>0.05), 术后 2 个月、12 个月及末次随访 SCA-LP 组、MP-LP 组均明显大于 LP 组(*P*<0.05)。三组间术后即刻、2 个月、12 个月及末次随访的平均椎管面积增加百分比差异无统计学意义 (*P*>0.05)。末次随访时,SCA-LP 组患者 C7 的椎管面积较术前增加(70.25±10.41)%,MP-LP 组 C7 增加 (61.03±8.76)%,差异有统计学意义(*P*<0.05)。SCA-LP 组的典型病例见图 3。

3 讨论

3.1 保留颈后肌肉韧带复合体的改良 LP

Yoshida 等[8]最早报道了保留颈后肌肉韧带复合体的椎管扩大双开门术, 作者认为保留肌肉韧带复合体可以减少部分肌肉韧带的剥离。但其随后的研究结果提示该术式对患者的轴性症状没有显著性改善[9]。Tani 等[10]将上述保留颈后肌肉韧带复合体的椎管扩大双开门手术方法改进为保留颈后肌肉韧带复合体的 LP。研究认为该技术降低了术后轴性症状的发生率[11],这与之前的报道结果完全相反, 保留肌肉韧带复合体是否能够改善轴性症状存在争议。国内学者也有类似的报道[12]。但是该方法需要破坏棘突的完整性、铰链侧仍需剥离深层的肌肉韧带、需要重建棘突的稳定性,颈后肌肉韧带复合体的力学作用也大大降低了[13]。

3.2 肌肉间隙入路的改良 LP

传统的颈后路单开门 LP 需要破坏深层伸肌,如果能有效保留深层伸肌的完整性,对颈椎的运动功能及颈椎稳定性可能会有积极意义。文献报道使用最多的肌肉间隙法是两侧通过头半棘肌和颈半棘肌之间的肌肉间隙。通过肌肉间隙的方法,减少了手术创伤,可能对维持颈椎曲度、降低术后轴性症状的发生率有一定的帮助[14-16]。但是,该方法需要剥离深面的多裂肌、颈回旋肌,对上述肌肉的破坏比较严重;同时,由于肌肉间隙长度有限,该术式只适合短节段的开门手术。国内也有学者采用双侧肌肉间隙入路的改良 LP[17],由于长节段手术, 对颈半棘肌直接损伤及间接牵拉损伤都很严重,又需广泛剥离深层的多裂肌及颈回旋肌,同样对椎旁肌肉造成较大范围的损伤。

3.3 SCA-LP

由于 LP 手术需要将颈后的肌肉韧带与骨面

表 4 各时间点 C2-C7 Cobb 角及平均椎管面积增加百分比

Table 4 Comparison of C2-C7 Cobb angle and the change of cross-sectional area of spinal canal

	C2-C7 Cobb 角(°) C2-C7 Cobb angle			平均椎管面积增加(%) Increased cross-sectional area of spinal canal		
	LP组 Group LP	MP-LP 组 Group MP-LP	SCA-LP 组 Group SCA-LP	LP组 Group LP	MP-LP 组 Group MP-LP	SCA-LP 组 Group SCA-LP
术前 Pre-OP	10.00±7.75	10.66±6.49	10.85±6.53	—	—	—
术后即刻 Immediately after operation	9.48±8.36	9.82±7.26	9.94±7.15	73.54±12.71	68.86±10.34	70.76±11.28
术后 2 个月 Po-2m	7.55±9.16①	9.63±7.08②	9.71±7.06②	73.48±12.25	68.46±10.81	70.17±11.73
术后 12 个月 Po-12m	4.83±8.25①	8.09±6.44①②	8.16±6.52①②	72.75±12.53	67.65±11.12	69.56±12.41
末次随访 Final follow-up	4.12±7.68①	8.06±6.57①②	8.03±6.41①②	72.06±12.32	67.26±11.08	69.13±11.76

注:①与同组术前比较 *P*<0.05;②与 LP 组比较 *P*<0.05

Note: ①Compared with preoperation, *P*<0.05; ②Compared with LP group, *P*<0.05

的止点彻底离断,术后患者常出现颈椎失稳、矢状面失衡,以及颈肩部疼痛酸胀、无力和僵硬等轴性症状。鉴于上述方法的不足,为了能够更大程度地保留颈后肌肉韧带的完整性,我们前期研究报道了 MP-LP 技术,MP-LP 的优点是:手术仅在开门侧操作,完全保留铰链侧肌肉韧带的完整性;手术创伤最小,术中出血最少,手术时间最短,患者恢复最快[7]。MP-LP 为患者的术后加速康复(enhanced recovery after surgery,ERAS)提供重要保障。通过对三种 LP 技术的对比,可以发现 MP-LP 的手术时间及平均住院日最短,术中出血量、术后引流量最小,手术仅在开门侧操作,完全保留铰链侧肌肉韧带的完整性,患者恢复最快。由于是单侧显露,对侧椎板、棘突都有肌肉韧带附着,如果对侧椎板断裂,由于肌肉韧带的牵拉,一般不会出现椎板移位而刺伤脊髓的风险。恰恰相反,由于对侧肌肉韧带的牵拉束缚,我们认为该技术可以减少脊髓损伤的风险。椎板断裂位置不可控,使得椎板旋转的铰链位置不固定,理论上可能会降低开门效果,但是我们的研究发现 MP-LP 与常规 LP 的椎板开门程度没有明显差异。我们把 MP-LP 开门的程度分为三个等级:一级开门就是通过骨的弹性形变扩大椎管;二级开门是在一级开门的基础上,对侧椎板内侧皮质断裂开口而出

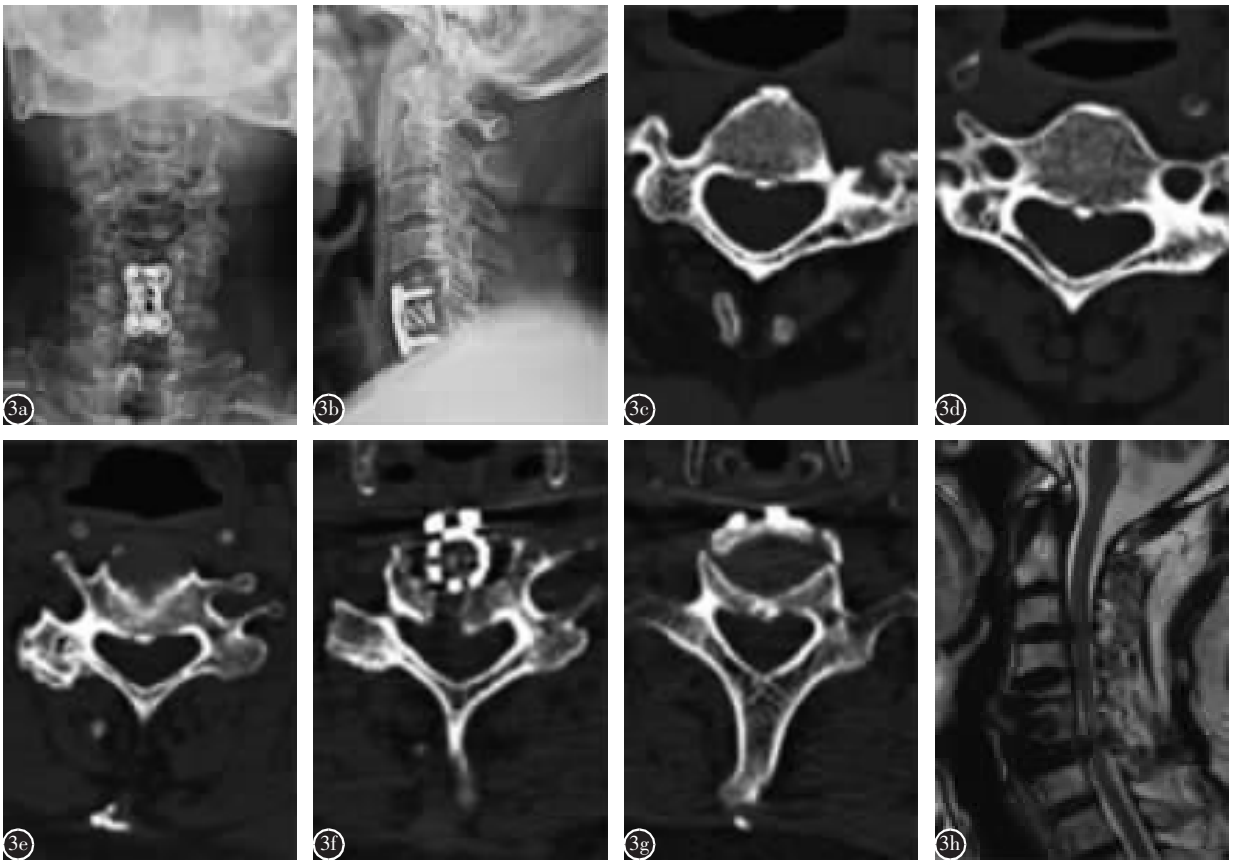

图 3 SCA-LP 组患者,70 岁,男性,因 MCSM 住院行 SCA-LP 手术治疗,既往有颈椎前路椎间盘切除减压植骨融合术(anterior cervical discectomy and fusion,ACDF)手术史 **a** 术前 X 线正位片显示患者颈前路内固定术后 **b** 术前 X 线侧位片示颈椎生理曲度减小、C5/6 植骨融合 **c~g** 分别为术前 C3~C7 的 CT 横断面,显示颈椎管狭窄,C5、C6 最为严重 **h** 术前矢状位 MRI 示多节段椎间盘突出、C6/7 黄韧带增生皱褶脊髓受压明显

Figure 3 A 70-year-old male patient in the SCA-LP group, hospitalized due to MCSM with a history of single level ACDF **a** Preoperative anteroposterior cervical X-ray film showed that the patient had undergone ACDF **b** Preoperative lateral cervical X-ray film showed that the physiological curvature of the cervical spine was reduced and C5/6 bone graft fusion **c-g** CT image of cross-section of C3-C7 before operation showed cervical canal stenosis and C5 and C6 the most serious **h** Preoperative sagittal MRI showed multi-level disc herniation, C6/7 ligamentum flavum hyperplasia and folds with obvious spinal cord compression

现了骨折;三级开门是在二级开门的基础上,对侧椎板内侧皮质断裂开口进一步加大、外侧皮质发生骨弹性形变[7]。与常规的 LP 相比,MP–LP 的优势非常明显,但对于椎板厚且骨质硬的患者,术中开门不会出现椎板骨折,甚至椎板弹性形变不足,连一级开门的程度都没有达到,而陷入开门失败的困境。从表 4 我们可以发现 MP–LP 在扩大 C3–7 平均椎管面积方面与其他两组没有明显差异,但其 C7 水平的椎管面积增加程度要显低于 SCA–LP 组,这说明了由于 C7 椎板较厚、骨质较

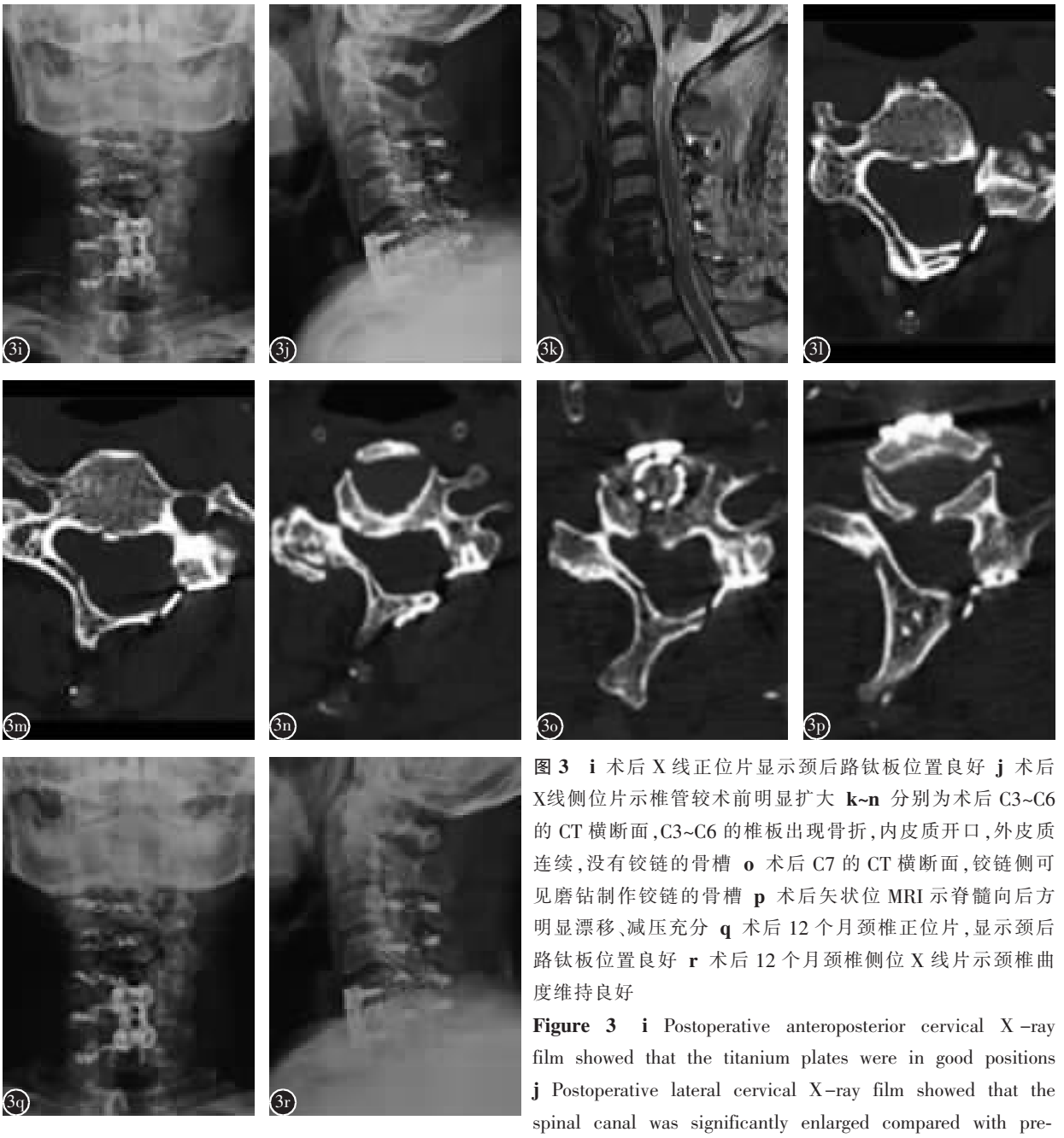

图 3 **i** 术后 X 线正位片显示颈后路钛板位置良好 **j** 术后 X线侧位片示椎管较术前明显扩大 **k~n** 分别为术后 C3~C6 的 CT 横断面,C3~C6 的椎板出现骨折,内皮质开口,外皮质连续,没有铰链的骨槽 **o** 术后 C7 的 CT 横断面,铰链侧可见磨钻制作铰链的骨槽 **p** 术后矢状位 MRI 示脊髓向后方明显漂移、减压充分 **q** 术后 12 个月颈椎正位片,显示颈后路钛板位置良好 **r** 术后 12 个月颈椎侧位 X 线片示颈椎曲度维持良好

Figure 3 **i** Postoperative anteroposterior cervical X–ray film showed that the titanium plates were in good positions **j** Postoperative lateral cervical X–ray film showed that the spinal canal was significantly enlarged compared with pre-operation **k–n** CT images of cross–section of C3–C6 after operation showed fractured C3–C6 laminae, the opened inner cortex, and continuous outer cortex without bone groove **o** CT image of cross–section of C7 after operation, the hinge made of grinding drill could be seen on the hinge side **p** Postoperative sagittal MRI showed that the spinal cord drifted backward significantly and decompression was sufficient **q** Anteroposterior radiographs of cervical spine at 12 months after operation showed that the titanium plates were in good positions **r** The lateral radiograph of cervical spine at 12 months after operation showed that the curvature of cervical spine maintained well

硬,MP-LP 术中很难将椎板掀开至骨折状态,部分患者仅达到一级开门程度。部分患者达不到一级开门程度,此时我们使用通道辅助下制作铰链(SCA-LP)完成开门手术,由于对侧有铰链,使得开门阻力大大降低,SCA-LP 组在 C7 水平的椎管面积增加程度要明显高于 MP-LP 组。所以 MP-LP 手术的适应证比较狭窄,这就限制了其在临床上的使用。

我们在临床上尝试在 C3~C7 的椎板旁经椎旁肌直接穿刺置入可扩张通道,通道下制作铰链,再进行开门手术,这样的改良术式我们称之为颈后路单侧显露通道辅助下椎管扩大椎板成形术(channel assisted laminoplasty,CA-LP)[18]。与传统的 LP 相比,CA-LP 技术没有破坏肌肉韧带于骨面的附着点,铰链侧的肌肉韧带的完整性得到了充分的保留,显著降低了铰链侧肌肉韧带的损伤。同时,铰链位置可控、开门过程的阻力小、开门效果有效肯定,两种手术方法的开门效果基本一致。CA-LP 技术需要每个椎板用一次通道,手术创伤较 MP-LP 略大,但其铰链侧有骨槽,开门阻力较小,开门过程更加容易操作;手术操作也不烦琐,通道下直视操作,没有改变医生的手术习惯,所以该术式的学习曲线非常平缓;该术式的手术适应证很广,与传统的 LP 手术适应证完全一样。该技术在骨化占位率较高、突出物侵占椎管较多、椎管狭窄较严重的患者中尤为适用,CA-LP 技术既能保证多个椎管的充分扩大,又能充分保留铰链侧肌肉韧带的完整性。

相对于 CA-LP 技术,MP-LP 技术完全单侧显露、对侧肌肉韧带的保留程度更大、手术创伤更小,在使用过程中,常会出现 C7、C6 椎板开门不足的情况,由于 C7、C6 椎板较厚、骨质较硬,术中很难将椎板掀开至骨折状态,部分患者可以达到一级开门程度,但一部分患者达不到一级开门的程度,陷入开门不足的困境。对于此类患者,我们在开门不足的部位,经椎旁肌直接穿刺置入可扩张通道,通道下制作铰链,再进行开门手术,这样的术式即为 SCA-LP 技术。该术式最大的优点是:既保证了充分的开门程度,又尽最大可能保留了铰链侧肌肉韧带的完整性。本研究结果显示,所有患者的 C7、12 例患者的 C6(30.77%)、6 例患者的 C3(15.38%)需要通道辅助下制作铰链。由于 C4、C5 椎板较薄,MP-LP 技术的旋转外力都能使椎板骨折而达到二级开门程度,因此 C4、C5 开门无需通道辅助。C7 的椎管面积增加程度 SCA-LP 组要优于 MP-LP 组,原因可能是由于 MP-LP 组 C7 椎板有部分是一级开门,SCA-LP 组的 C7 开门程度达到二级开门,椎管面积扩大的程度得到了进一步增加。

我们前期研究发现,将骨化物排除在椎管面积测量区域之外,所得结果将会明显变大,这样会导致 OPLL 患者的椎管面积增加百分比会明显大于 MSCM 及 CS 患者的结果,为了消除这种因测量方法导致的误差,我们采用了原始骨性椎管测量方法(椎管面积测量区域包含了骨化物区域)。

SCA-LP 技术对铰链侧肌肉韧带的保留程度介于 MP-LP 与 CA-LP 之间。MP-LP 完全单侧显露,对侧肌肉韧带的保留程度最大,手术最微创,但常出现开门阻力大、开门不足的情况;CA-LP 开门阻力最小、开门过程最容易,但穿刺置入通道,对侧肌肉韧带完整性仍有一定程度的损伤,尽管该技术没有破坏肌肉韧带与骨面的附着点。SCA-LP 融合了 MP-LP 与 CA-LP 的优点,在保证充分开门的前提下,尽最大可能保留铰链侧肌肉韧带的完整性。

该研究的不足之处在于:本研究处于早期阶段,入组的病例数还不够充足;缺乏长期随访结果。

总之,与常规的颈后路单开门 LP 相比,两种改良术式均能有效减少铰链侧肌肉韧带的损伤,术后加速康复,减少术后早期轴性颈痛的发生率。与 MP-LP 相比,SCA-LP 能更有效地增加椎管面积。

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(收稿日期:2022-07-17 末次修回日期:2022-11-06)

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