综述

颈椎后纵韧带骨化症治疗策略研究进展

Advances in surgical treatment of cervical ossification of the posterior longitudinal ligament

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颈椎后纵韧带骨化症（ossification of the posterior longitudinal ligament，OPLL）为颈椎后纵韧带呈现进行性高度骨增生的异位骨化，导致增生骨化的韧带压迫脊髓，椎管体积减小[1,2]，临床表现主要为脊髓病和或神经根病，伴有严重的神经病理学改变，导致肢体瘫痪和运动功能紊乱，降低生活质量。该病为 OPLL 的一种，并占 OPLL 总体发病率的 70%[3,4]，甚至在脊髓型颈椎病中的出现率高达 25%，是引起脊髓型颈椎病的主要原因之一[5]，应予高度重视。虽然早期的颈椎 OPLL 可保守治疗，但是在大多数颈椎 OPLL 患者中，病情是进展性的，甚至会导致毁灭性的神经系统并发症，如四肢轻瘫和四肢瘫痪，因此常需手术治疗[6,7]。现阶段临床中，治疗颈椎 OPLL 的手术方式可依据手术入路的选择分为前入路手术、后入路手术、后前入路联合手术。本研究将近 10 年发表于 CNKI 及 Medline 中有关颈椎 OPLL 的手术策略之适应证及优缺点进行如下综述。

1　颈椎前入路手术

经颈前方入路，对脊髓进行直接减压的手术方式，主要包括传统的颈椎前路椎体次全切除融合术（anterior cervical corpectomy and fusion，ACCF）和颈椎前路椎间盘切除减压植骨融合术（anterior cervical discectomy and fusion，ACDF），颈椎前路漂浮减压术（anterior cervical decompression with floating method，ADF），以及新兴的前路椎体骨化物复合体前移融合术（anterior controllable antedisplacement fusion，ACAF）[8]。

1.1　传统的 ACCF 及 ACDF

Smith 等[9]于 1958 年首次提出颈椎前路减压植骨融合手术后，经过几十年的发展和改进，目前已被广泛运用于颈椎退行性病变、肿瘤、外伤及感染性病变的治疗中。其中，于 20 世纪由 Saunders 等[10]首先报道的 ACCF 及 20 世纪中期 Cloward 等[11]首先报道的 ACDF 是临床上最为常见的两种颈前路手术方式。在颈椎 OPLL 的治疗中，其经颈椎前方入路对脊髓受压节段进行直接减压并固定，可充分减压并重建颈椎生理曲度，疗效确切。其优势在于：(1)可直接切除致压的骨化韧带，使脊髓获得直接减压[12]；(2)术中可撑开椎间重建颈椎生理曲度；(3) 术中可观察致压物与硬膜囊的关系及减压后的恢复状态，对预后的判定至关重要[13]；(4)可解除对脊髓前动脉的压迫，明显改善脊髓的血供，有助于神经功能恢复[14]；(5)可切除骨化灶，减少脊髓迟发性损害及术后的骨化进展，并有效预防因脊髓后移而产生的神经根牵拉以及主要由颈椎后方结构破坏导致的轴向症状的发生，有利于脊髓在相对正常的生理环境下恢复[14,15]。其不足在于：(1)手术术野小，操作复杂，技术难度大，对医生经验要求高[16]；(2)当骨化灶累及高位或低位颈椎时，前路手术暴露困难[17]；(3)手术易造成副损伤，特别是当术中出血视野受限，或骨化灶伴硬膜骨化时，并发脑脊液漏、吞咽困难、声音嘶哑的风险高[18]；(4)当骨化灶累及多个节段（超过 3 个节段以上时），单纯前路手术对颈椎完整性破坏较大，术后易出现植骨不融合、钛网塌陷及内固定失效等问题[19]；(5)当骨化灶累及 C2 以上节段，前路手术效果不佳[19]。遂现阶段研究普遍认为[20-22]，ACCF 及 ACDF 在颈椎 OPLL 的治疗适应证为：(1)骨化灶累及局限于 C2 以下节段；(2)骨化灶累及<3 个节段；(3)椎管有效矢状径≥5mm；(4)节段型或局限型颈椎 OPLL，骨化物占位率>50%，并无进行性椎管狭窄。

1.2　ADF

ADF 于 1991 年由 Kamikozuru 等[23]首先提出，多用于骨化物与硬膜粘连，或有硬膜骨化的中重度颈椎 OPLL 患者。其手术的基本过程为暴露骨化物，将骨化物打薄至厚度<5mm，使其形成贝壳样弧度后，通过解除整个骨化物与椎体的连接使骨化物漂浮。漂浮的骨化物在脑脊液的压力下缓慢向前漂移，达到减压效果[24]。其优势在于：(1)并不完全切除骨化病灶，而是将其旷置，避免了直接切除骨化的后纵韧带易造成的脊髓损伤风险[25]，并且长期随访显示，若同时将增生的韧带纳入减压范围，术后可阻止骨化

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物再生长[24]；(2)术中参考点为 Luschka 关节，手术时不直接接触椎动脉及神经组织，降低了损伤的可能[25]；(3)对位于后纵韧带浅层及硬膜外腔的椎内前静脉丛的干预极少，减少了术中出血[26]；(4)与硬脊膜粘连的骨化灶在脑脊液的压力下缓慢向前漂移，使硬膜缓慢膨胀，避免了硬膜急性膨胀带来的脊髓水肿和再灌注损伤等不良后果[24]；(5)可有效避免硬膜撕裂及脑脊液漏的发生，特别对于合并硬膜骨化或硬膜与骨化灶粘连的患者[27]；(6)解除脊髓前方的骨性压迫，获得较好的神经功能改善[28]的同时，重建颈椎生理曲度[29]。其不足在于：(1)手术技术及操作难度大，学习时间长[25]；(2)截骨范围较大，椎体可能被修剪到错误的方向[24]；(3)对于侧方生长及宽基底型的颈椎 OPLL，由于骨化灶较宽，两侧游离时较为困难，影响漂浮效果[25]；(4)对于多节段颈椎 OPLL(大于 2 个节段)，甚至合并颈椎后凸畸形的患者，虽长期随访显示其有效性，但是其并发症也显著提高，如移植物反应、植骨不融合、植骨脱位、延迟愈合及血肿引发的呼吸困难等；(5)当骨化灶累及 C2 以上节段，前路手术效果不佳[19]。遂现阶段研究认为其适应证为：(1)骨化灶累及局限于 C2 以下节段[19]；(2)颈椎 OPLL 合并硬膜骨化或硬膜与骨化灶粘连的患者[30]；(3)高度的局部、连续或混合型狭窄，后路减压效果不确切；(4)术前 CT 显示骨化灶无向外侧生长的非宽基底型颈椎 OPLL[31]。

1.3 ACAF

ACAF 为 2017 年由史建刚团队率先提出的一种治疗颈椎 OPLL 的新型手术方式[8]。其基本过程为经前路钩突定位，截椎骨于骨化物一侧，将骨化物前方的椎体连同骨化物一同置入螺钉桥后，行另一侧截骨，将骨化物及其前方椎体游离，旋紧螺钉使骨化物前移并固定，达到减压及重建颈椎生理曲度的效果。其优势在于：(1)不直接切除骨化灶，降低了手术难度，提高了手术的安全性[32]；(2)虽是前路减压，但其操作区域位于脊髓外侧的钩椎关节附近，在解剖结构上降低了截骨时脊髓损伤的风险[33]；(3)减压宽度理论上可达 18~20mm，减压范围广，可对脊髓及神经根同时减压[34]，并对宽基底型颈椎 OPLL 减压效果好[8]；(4)可作为翻修手术，且对神经功能的改善有很好效果[35]；(5)避免了脊髓后移，防止出现 C5 神经根麻痹等[36]并发症，同时避免了直接切除椎体，增加了术后颈椎的稳定性[37]；(6)对颈椎生理曲度改善明显[38]，并且对颈椎后方结构无损伤，减少术后轴性症状的发生[39]。其不足在于：(1)如患者合并硬膜骨化粘连，术中牵拉椎体骨化物复合体时容易撕裂硬脊膜导致脑脊液漏或血肿的发生[40]；(2)双侧截骨时开槽宽度较大，靠近椎动脉，易导致椎动脉受损，特别当椎动脉变异，如屈曲变形、向内侵蚀横突孔内壁等存在时[33]；(3)涉及 C1、C2 的颈椎 OPLL，前路手术效果不佳[19,41]；(4)骨化的后纵韧带如游离于周围骨皮质，ACAF 达不到减压效果[42]；(5)术中开槽方向很难把握，容易出现偏斜，导致术者侧开槽宽度不足碰到骨化灶，对侧开槽过宽达到椎弓根[37]。因该术式为近期新兴术式，术后并发症、融合率、骨化物进展、神经功能改善情况等方面仍需要进一步的长期随访后才可确定，遂其适应证现并不明确。目前认为，其最佳适应证为：(1)骨化灶累及局限于 C2 以下节段[19]；(2)颈椎 OPLL 之骨化物与前方椎体连接紧密，与后方硬膜并无连接或连接松弛[43]；(3)ACCF 难以切除的巨大颈椎 OPLL 以及 ACCF 术后难以重建的长节段颈椎 OPLL[44]；(4)行后路手术后骨化进展或后凸畸形的补救手术[45]。

2 颈椎后入路手术

经颈后方入路，对脊髓进行间接减压的手术方式，主要包括椎管扩大椎板成形术(laminoplasty，LAMP)、椎板切除术(laminectomy，LAME)以及新兴的后路 Hybrid 手术(posterior hybrid technique)。

2.1 LAMP

LAMP 自 1978 年由 Hirabayashi(平林洌)等[46]提出并经过数十年的改良发展演变为单开门[47]及 Kimura 等[48]提出的双开门微钛板固定椎管扩大椎板成形术，为目前治疗颈椎 OPLL 最常用的的手术方式。其主要通过将颈椎后方多个椎板向一侧或双侧掀开，扩大椎管的容积，并利用颈椎的生理前凸，依据“弓弦”原理，使脊髓后荡，有效地避开前方的压迫，达到减压的效果[47]。其优势在于：(1)操作相对简单，对颈椎的结构破坏较少，手术时间相对缩短，术中出血量少，手术创伤小[46]；(2)对于累及 C2 以上的颈椎 OPLL 疗效较好[49]；(3)有效扩大椎管矢状径，减压节段长，减压范围充分，可充分缓解脊髓受压[7,49]；(4)脊髓的后移降低了轴向张力，促进脊髓血供恢复，有利于神经功能恢复[50]；(5)对脊髓的刺激或损伤小，不易损伤脊髓、血管及神经[49,51]；(6)保留椎板，使脊髓在术后仍有骨性结构保护，限制脊髓过度后移并防止术后发生医源性椎管狭窄[37]；(7)通过微钛板的支撑，避免了再关门发生[52]；(8)保留了颈椎活动度[53]，术后邻近节段退变减慢，并避免颈部僵硬不适，可以提早进行颈部锻炼，术后颈部疼痛程度明显降低[54]。其不足在于：(1)间接减压，减压效果不如前路[55,56]；(2)难以阻止术后病情进展，如骨化块增厚[57~59]；(3)脊髓后移可能造成神经根牵张损害，使术后原症状加重或出现新的神经根症状，如 C5 神经根麻痹[60]；(4)对脊柱后方结构损伤较大，术后易出现轴性症状[61,62]，并可能导致颈椎曲度丢失及颈椎失稳甚至后凸畸形，导致脊髓再次受压，出现神经功能恶化[63~66]；(5)对椎管侵占率大于 60%，K 线阴性及术前存在后凸畸形，脊髓不能充分后移者效果不佳[67]；(6)如合并有齿状韧带、神经根、根套粘连于椎管或硬膜，后路减压效果差[31]。遂现阶段研究表明[49,68~71]其适应证为：(1)骨化灶累及 C1、C2，或延伸至胸椎者；(2)≥3 个节段的连续型、混合型颈椎 OPLL；(3)进行性、先天性、发育性椎管狭窄；(4)颈椎 OPLL 合并脊髓后方的压迫，如黄韧带增生肥厚及骨化；(5)K 线阳性，椎管侵占率小于 60%，并无明显后凸畸形的颈椎 OPLL。

2.2 LAME

LAME 于 1986 年由 Miyazaki 等[72]首先报道，通过将椎板部分或全部切除，使脊髓后移从而实现脊髓的充分减压。曾作为治疗严重颈椎 OPLL 的主要术式，对颈椎生理曲度良好的患者具有较好效果[37]。主要包括非融合单纯椎板切除术以及侧块螺钉融合的椎板切除术，而非融合单纯椎板切除术由于远期发生后凸畸形的风险高，现已逐渐被侧块螺钉融合的椎板切除术所取代[27,73]。侧块螺钉融合的椎板切除术的优势在于：(1)减压范围大而彻底，可扩张椎管容积达 70%~80%[74]；(2)钉棒系统固定提供稳定性可减少椎间不稳，并减缓骨化进展[57]。并且 Fujimura 等[75]发现，当颈椎 OPLL 合并创伤时，术后颈椎活动度与恢复率成负相关性，通过钉棒系统的固定提供稳定性可提高恢复率；(3)融合固定后，短期内可预防后凸畸形[76]，并维持矢状面平衡[39]。其不足在于：(1)对脊柱后方结构损伤较大，术后易出现轴性症状[77,78]；(2)切除椎板后，脊髓后方无骨性遮挡，瘢痕组织易压迫脊髓导致术后二次狭窄，并且骨性遮挡消失，易导致 C5 神经根麻痹[79,80]；(3)以损失下颈椎大部分活动度为代价，术后易导致颈部僵硬，生活质量受到影响[81]；(4)后方植骨融合，术后融合效果不良，椎间存在微动，导致骨化进展，并且长期随访发现这种术式远期易发生内固定失效，甚至后凸畸形[82-84]。其在颈椎 OPLL 治疗中的适应证为：(1)骨化灶累及 C1、C2，或延伸至胸椎者[49]；(2)≥3 个节段的连续型、混合型颈椎 OPLL[68]；(3)存在颈椎半脱位[85]（静态侧位 X 线片提示颈椎半脱位>3.5mm；动态侧位 X 线片提示颈椎半脱位>4.0mm）；(4) 存在节段性不稳[85]（动力位 X 线片单一节段椎体后缘位移≥3.5mm 或角度差≥11°）；(5)K 线阴性、椎管侵占率大于 60%及颈椎曲度变直或后凸畸形[86]；(6)颈椎 OPLL 合并脊髓损伤需广泛减压者[75]。

2.3 后路 Hybrid 手术

后路 Hybrid 手术由 Matsumura 等[87]于 2003 年首先提出，其由最初的改良后的黑川式劈裂法联合棘间髂骨植骨并后路侧块钢板，发展至现阶段的后路微钛板扩大成形术联合后路融合侧块螺钉固定术。是通过椎板单开门扩大狭窄颈椎管前后径，进行有效减压后，在颈椎不稳节段进行后路的有限固定，恢复颈椎曲度并提供稳定[88]。因其为侧块螺钉融合的椎板切除术的改良术式，遂其适应证为除骨化物占椎管容积的 60%以上的颈椎 OPLL，其余可行侧块螺钉融合的椎板切除术的患者[89,90]。在侧块螺钉融合的椎板切除术所有的优势基础上，后路 Hybrid 手术优点：(1)脊髓后方有骨性及金属遮挡，可减少 C5 神经根麻痹的发生率[88]，可减少瘢痕组织压迫导致的术后二次狭窄[90]；(2)在颈椎不稳定节段行有限固定减慢术后不稳定节段的骨化进展并恢复颈椎曲度[89]，保留其他单开门节段颈椎的活动能力，减少术后颈部僵硬的发生[91]。其不足在于：(1)费用较高，操作较烦琐[82]；(2)后路钉棒系统只提供了前期稳定，后期融合效果不佳易导致节段间发生微动导致术后病情进展，如骨化块增厚[57]，甚至导致内固定失效，后凸畸形发生[82]；(3)对脊柱后方结构损伤较大，术后易出现轴性症状[63,77,78]；(4)对椎管侵占率大于 60%的患者，减压程度可能不够，效果不佳[67]；(5)如合并有齿状韧带、神经根、根套粘连于椎管或硬膜，后路减压效果差[31]。

3 颈椎后前入路联合手术

为先经颈后方入路，对脊髓进行间接减压后，径前入路手术对脊髓进行直接减压的手术方式。主要包括传统的后前路联合手术（posterior-anterior approach surgery）以及新兴的改良后前路联合手术（modified posterior-anterior approach surgery）。

3.1 后前路联合手术

后前路联合手术由 Epstein 等[92]于 1989 年提出，通过后路的椎板切除或者发展至今的椎管扩大椎板成形术使脊髓充分后移，减少前路手术损伤脊髓的风险后，1 期或分期行前路手术，直接切除相应节段骨化增生物，达到充分减压，并且提供良好的固定以及融合的目的[93]。其优势在于：(1)先行后路椎管扩大椎板成形术使脊髓向后漂移，前方致压物对其压迫减轻，再行前路手术有效地减少了前路手术的风险[94]，并能够充分彻底地解除脊髓前后方的压迫[92]；(2)前路固定可恢复颈椎的生理曲度、稳定颈椎、融合效果好、避免后凸畸形的发生，并且防止骨化进展[79,95]；(3)前路稳定固定，术后可获得即刻稳定，患者可以早期活动[94]；(4)分期手术赢得了脊髓恢复的时间，神经功能恢复优势明显[96]。其不足在于：(1)手术费用大，住院时间长[97]；(2)手术时间长，术中出血量大，对患者的打击大[93]；(3)颈椎活动度丢失[98]；(4)需长期应用外部支撑，轴性症状发生率高[99]。遂其适应证为：(1)身体状况良好，可耐受前路及后路减压的患者；(2) 发育性椎管狭窄，重度椎管狭窄>60%，前路减压风险及难度较大者[100]；(3)合并硬膜骨化多节段颈椎 OPLL 患者，前路手术风险较大，后路手术减压不完全[101]；(4)连续型或混合型骨化灶超过 4 个椎节以上，厚度大于 5mm，椎管严重狭窄且脊髓前后均受压迫[93,102]。

3.2 改良后前路联合手术

改良后前路联合手术由毕郑刚团队于 2002 年率先提出，其根据患者骨化物的滞压情况，如压迫集中于单侧则行后路单开门椎管扩大管椎板成形并行前路的椎间融合固定，但不行前路的减压手术；如骨化物较大，双侧压迫，则行后路的全椎板切除并行前路的椎间融合固定，但不行前路的减压手术。于术中但保留 C7 棘突和 C2 颈半棘肌附着点，行椎间孔切开，小关节突切除（小于 50%）。研究发现这种改良后前路联合手术，术后患者骨化物有明显回缩趋势[82]，打破了诸多学说认为的不论何种术式患者术后骨化物均会进展的理论[57-59]。这种手术目的在于研发一种对于 K 线阴性多节段（大于 3 个节段）重度颈椎 OPLL 的治疗方针[82]，遂其适应证也为此类患者。其优势在于：(1)因不做前路的减压手术，手术操作简单，手术时间短，

术中失血量及输血量少[82]；(2)住院时间，住院花费相对减少[82]；(3)临床疗效好，术后并发症少[82]；(4)后移降低了脊髓的轴向张力，促进脊髓血供的恢复，有利于神经功能的恢复[50]；(5)椎间孔切开小关节突切除预防 C5 神经根麻痹的发生[103]；(6)良好纠正颈椎曲度，并且随着研究的进展，发现 K 线阴性的颈椎 OPLL，颈椎的曲度几乎均变直，甚至反曲，这就意味着后路的钉棒固定系统并不能像前路手术那样良好的重建颈椎生理曲度；(7)术中保留 C7 棘突及 C2 颈半棘肌附着点，从而减少术后轴性症状的发生[39,61]；(8)前路稳定，阻止后凸畸形及骨化进展的发生，并且研究发现，这种改良后前路联合手术，术后患者骨化物有明显回缩趋势[82]；(9)前路融合术后前期更加稳定[104]、术后疼痛小、感染少、融合率最高[105]。但该术式仍有些许不足之处，如这种术后仅适合 K 线阴性多节段颈椎 OPLL，对于 K 线阳性的患者，有扩大手术的风险。并且这种长节段固定，会导致患者术后颈椎活动度下降[98]。

4 总结与展望

综上所述，现阶段各类手术方式均有其有优势及不足，并无一种手术方式可以完美地治愈颈椎后纵韧带骨化症这项疾病。而 K 线的提出及改良，为手术入路提供了参考[68,106]。综合现阶段研究，对于小于等于 2 个节段的颈椎 OPLL，可行 ACCF 及 ACDF 基本已达成共识[20~22]；对于 K 线阳性并大于 2 个节段的颈椎 OPLL，行后路椎管扩大椎板成形术也已基本达成共识[49,68~71]。而对于 K 线阴性的患者，手术入路的选择仍存在争议[55,100,107]。史建刚团队的首创 ACAF 以及毕郑刚团队首创的改良后前路联合手术现阶段确实对于此类患者取得了较好疗效，但由于截至目前手术例数较少，没有经长时间，大样本多中心临床研究，遂其远期疗效如何并不确定，需要长期随访观察。而随着术中 CT 及 3D 建模打印的问世，如将术中 CT 及 3D 建模打印结合于颈椎 OPLL 手术中，其术中的精准及安全势必大幅度提高。并且，随着对于 OPLL 病理及发病机制的研究，一些新型的非手术治疗方案现已提出，如 Shi 等[108]发现通过低浓度地塞米松诱导，OPLL 模型中的转录因子 Osterix 可通过抑制 Wnt-β catenin 信号通路阻止异位骨化，这就为 OPLL 的病因治疗提供了可能。而对于现阶段临床医生在颈椎 OPLL 的手术治疗中，应做到充分了解患者症状体征，严格做好影像学检查，根据骨化物大小、类型、椎管侵占程度、受累节段数量、K 线的测量结果、颈椎曲度的改变，合理有效的制定手术方案，做到颈椎 OPLL 手术的微创、精准、实效、安全。

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