临床论著

椎体 CT 值在预测颈椎前路融合术后早期内置物沉降中的应用价值

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【摘要】**目的**:研究颈椎椎体 CT 值在预测颈椎前路融合术后早期内置物沉降中的应用价值。**方法**:回顾性分析 2017 年 1 月~2018 年 6 月北京大学第三医院颈椎专业组收治的 306 例行颈椎前路融合手术的颈椎退行性疾病患者的临床资料。在影像归档和通信系统(picture archiving and communication system,PACS)上测量 C2~C7 椎体中横断面的 CT 值,通过双能 X 线吸收法(dual-energy X-ray absorptiometry,DXA)获得 L1~L4 总的骨密度 T 值。在术后第 2 天、术后 3 个月颈椎中立侧位 X 线片上分别测量颈椎前路融合节段前、后缘高度和融合节段 Cobb 角。定义术后 3 个月较术后 2d 融合节段前、后缘高度丢失的平均值≥2mm 为内置物发生沉降。采用 Spearman 秩相关检验腰椎骨密度 T 值与 C2~C7 椎体 CT 均值的相关性,采用 Spearman 秩相关检验 C2~C7 椎体 CT 均值、腰椎骨密度 T 值分别与融合节段高度丢失数值、融合节段 Cobb 角改变的相关性。采用 Logistic 回归模型,分别检验 C2~C7 椎体 CT 均值、腰椎骨密度 T 值与沉降的关联。以沉降为标准,采用受试者工作特征(ROC)曲线确定 C2~C7 椎体 CT 均值的临界值。**结果**:术后 3 个月明确发生沉降 122 例,未发生沉降 184 例,沉降发生率为 39.9%。C2~C7 椎体 CT 均值与腰椎骨密度 T 值呈显著正相关(r=0.518,P<0.001),与融合节段 Cobb 角改变有显著相关性(r=-0.170,P=0.003),呈负相关。但腰椎骨密度 T 值与融合节段 Cobb 角改变无显著相关性(P=0.605)。融合节段高度丢失值与 C2~C7 椎体 CT 均值无显著相关性(P=0.056),与腰椎骨密度 T 值无显著相关性(P=0.274)。采用 Logistic 回归模型,控制性别、术式和节段的影响后,内置物沉降与 C2~C7 椎体 CT 均值有显著相关性(P=0.035),CT 值每升高 1HU,沉降风险降低 0.4%(OR=0.996,95%CI:0.992~1.000);控制性别、术式和节段的影响后,内置物沉降与腰椎骨密度 T 值的无显著相关性(P=0.098)。以沉降为标准,采用 ROC 曲线分析,曲线下面积为 0.562,ROC 曲线上最佳 C2~C7 椎体 CT 均值为 273HU。**结论**:预测颈椎前路融合术后早期内置物沉降时颈椎椎体 CT 值要优于腰椎骨密度 T 值,术前较高的颈椎椎体 CT 值患者术后发生内置物沉降的风险较低。

【关键词】颈椎前路融合手术;沉降;CT 值;T 值;骨密度
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【**Abstract**】 **Objectives:** To investigate the application of CT value of cervical vertebrae in predicting early internal plant subsidence after anterior cervical fusion. **Methods:** A retrospective analysis was performed on 306 patients with cervical degenerative diseases who underwent anterior cervical fusion surgery from January 2017 to June 2018 in the Cervical Spine Group of Orthopaedic Department of the Third Hospital of Peking University. The CT values of cross-sectional C2-C7 vertebrae were measured on the picture archiving and communication system(PACS), and the total bone mineral density(BMD) T values of L1-L4 were obtained by dual-energy X-ray absorptiometry(DXA). The heights of the anterior and posterior edges of the fusion segment

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and the Cobb angle were measured on neutral lateral radiograph of cervical spine on day 2 and at month 3 after operation. The average height loss of the anterior and posterior edges of the fusion segment ≥2mm between 3 months and 2 days after surgery was defined as subsidence of the implant. Spearman′s rank correlation was used to test the correlation between the lumbar BMD T value and the C2-C7 CT mean value, as well as the correlation between the C2-C7 CT mean value, the lumbar BMD T value and the height loss and the Cobb angle change of fusion segments, respectively. Logistic regression model was used to test the correlations between the C2-C7 CT mean value, the lumbar T value and the subsidence. Taking subsidence(≥2mm) as the standard, the critical value of C2-C7 CT mean value was determined by using the receiver operating characteristic(ROC) curve. **Results:** There were 122 cases of subsidence and 184 cases of non-subsidence at 3 months after operation. The incidence rate of subsidence was 39.9%. There was a significant positive correlation between the C2-C7 CT mean value and the lumbar T value(r=0.518, P<0.001). There was a significant negative correlation between the C2-C7 CT mean value and the change of Cobb angle of the fusion segment(r=-0.170, P=0.003). However, there was no significant correlation between the lumbar T value and the change of Cobb angle of the fusion segment (P=0.605). There was no significant correlation between the height loss of the fusion segment and the C2-C7 CT mean value (P=0.056) or the lumbar T value (P=0.274). Using Logistic regression model, after adjusting gender, operation style and segment, the correlation between the subsidence and the C2-C7 CT mean value was statistically significant (P=0.035), as an increase of per 1HU in CT value decreasing the subsidence risk by 0.4%(OR=0.996, 95%CI: 0.992-1.000); After adjusting gender, operation style and segment, the correlation between the subsidence and the lumbar T value was not statistically significant(P=0.098). Taking the subsidence as the standard, the area under the curve of ROC curve was 0.562, and the best C2-C7 CT mean value on the ROC curve was 273HU. **Conclusions:** The CT value of cervical vertebrae was superior to the lumbar T value when predicting the early subsidence of internal implants after anterior cervical fusion surgery. Patients with higher preoperative CT value of cervical vertebral had lower risk of implant subsidence after surgery.

【Key words】 Anterior cervical fusion surgery; Subsidence; CT value; T value; Bone mineral density

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随着我国进入老龄化社会，脊柱外科医师面临的骨质疏松患者越来越多，这为脊柱手术带来了诸多挑战。颈椎前路手术中，骨质疏松可能会导致内置物发生沉降、钢板移位等并发症[1]，因此术前患者的骨密度评估尤为重要。目前评估骨密度的金标准是双能 X 线吸收法（dual X-ray absorptiometry，DXA），但由于其测量部位在腰椎和股骨近端，所以在颈椎手术中的应用价值有一定争议。相关研究显示，颈椎椎体 CT 值与 DXA 检查的腰椎骨密度 T 值呈正相关，有助于术前临床评估患者手术节段椎体的骨密度[2]。然而，颈椎椎体 CT 值在预测颈椎椎间融合术后发生内置物沉降方面的研究尚未见报道。本研究拟通过回顾性分析颈椎前路融合手术后早期内置物的沉降与术前患者不同骨密度评估方法的相关性，探究颈椎椎体 CT 值在预测颈椎前路融合术后早期内置物沉降中的应用价值。

1 资料与方法

1.1 纳入及排除标准

纳入标准：(1)在北京大学第三医院骨科颈椎专业组进行颈椎前路融合手术，包括颈椎前路椎间盘切除减压植骨融合术（anterior cervical discectomy and fusion，ACDF）、颈椎前路椎体次全切除减压植骨融合术（anterior cervical corpectomy and fusion，ACCF）、颈椎前路椎间盘切除零切迹椎间融合术(Zero-Profile device，Zero-P)。(2)术前 1 个月内均在北京大学第三医院行颈椎三维 CT 检查及 DXA 骨密度检查。术后第 2 天、术后 3 个月行颈椎正侧位 X 线检查。

排除标准：(1)既往颈椎及腰椎骨折及手术史者；(2)颈椎及腰椎骨质破坏(如肿瘤、感染等)者。(3) 术后颈椎中立侧位 X 线片融合节段被遮挡，无法在 PACS（picture archiving and communication system)系统上进行测量。

1.2 一般资料

2017 年 1 月~2018 年 6 月在北京大学第三医院骨科颈椎专业组接受颈椎前路融合手术并且符合入选标准及排除标准的患者共 306 例，其中男性 122 例，女性 184 例，年龄 41~84 岁(58.6±6.8 岁)。包括 ACDF 210 例，其中单节段 58 例，双节段 110 例，三节段 41 例，四节段 1 例；ACCF 55 例，其中单节段 45 例，双节段 10 例；Zero-P 41 例，其中单节段 33 例，双节段 6 例，三节段 2 例，所有手术均由同一组术者完成。

1.3 观察指标

根据患者术前的颈椎三维 CT，应用 PACS 系统[RA1000 3.0 版，通用电器医疗系统(中国)有限公司]分别测量 C2~C7 椎体的 CT 值。CT 值的测量方法：在 C2~C7 椎体矢状面重建的中横断面上，圈定尽量大的目标区域，该区域不包括皮质骨及骨质异常区域，如骨岛、静脉窦、压缩骨质(图 1)。每一椎体的 CT 值由 PACS 系统计算所得，CT 值与 CT 的窗位无关，并计算出平均值。同时收集每例患者术前 DXA 所测得的 L1~L4 总的骨密度 T 值。分别在术后第 2 天及术后 3 个月颈椎中立侧位 X 线片上测量融合节段前缘及后缘高度，测量融合节段 Cobb 角(图 2)。高度丢失=(前缘高度丢失+后缘高度丢失)/2。沉降定义为术后较术前融合节段前、后缘高度丢失的平均值≥2mm[3,4]。测量时影像均放大 4 倍，因测量误差，测量术后第 2 天及术后 3 个月时 C1 矢状径，对术后 3 个月时融合节段前、后缘高度进行校正。比如，术后 3 个月经校正前缘高度=术后 2 天 C1 矢状径×术后 3 个月前缘高度/术后 3 个月 C1 矢状径。

1.4 统计学方法

采用 SPSS 20.0 统计学软件进行统计分析，采用双侧检验，$P<0.05$ 表示有统计学意义。采用 Spearman 秩相关检验腰椎骨密度 T 值与 C2~C7 椎体 CT 均值的相关性，采用 Spearman 秩相关检验 C2~C7 椎体 CT 均值、腰椎骨密度 T 值分别与融合节段高度丢失数值、融合节段 Cobb 角改变的相关性。采用 Logistic 回归模型，分别检验 C2~C7 椎体 CT 均值、腰椎骨密度 T 值与沉降(≥2mm)的关联，模型中控制性别、术式和节段。采用受试者工作特征(ROC)曲线分析 C2~C7 椎体 CT 均值预测测颈椎前路融合术后早期置入物塌陷的价值，并通过正确指数(灵敏度+特异度-1)最大原则确定引起沉降的 C2~C7 椎体 CT 均值临界值。

2 结果

2.1 沉降发生率

纳入研究的 306 例患者术后 3 个月时明确发生沉降者 122 例(图 3)，沉降发生率为 39.9%，未

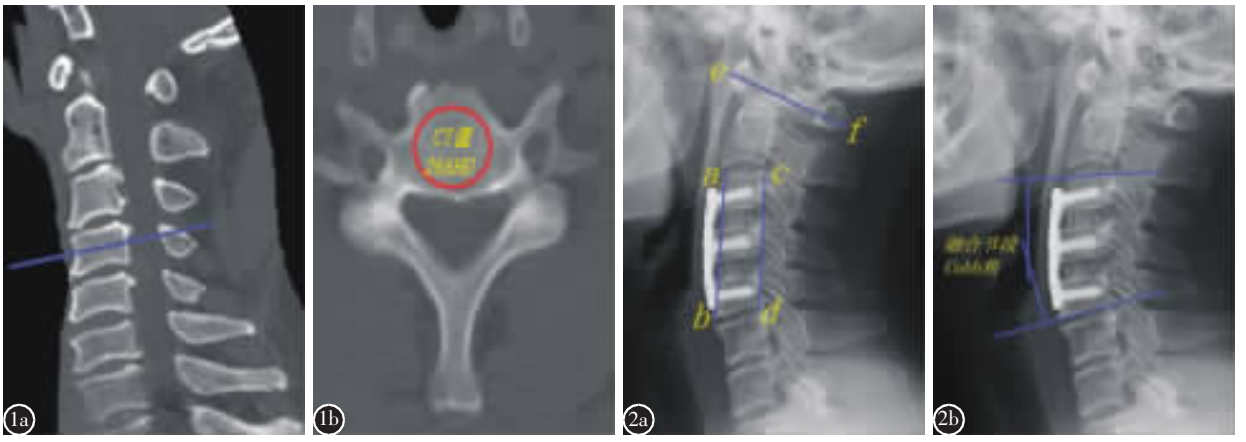

图 1 颈椎椎体 CT 值测量 **a** 在颈椎 CT 矢状面重建图片上进行定位 **b** 在中横断面上测量 CT 值 **图 2** **a** 在颈椎中立侧位 X 线片上测量融合节段前后缘高度，ab 为前缘高度，cd 为后缘高度，ef 为 C1 矢状径 **b** 在颈椎中立侧位 X 线片上测量融合节段 Cobb 角

Figure 1 The measurement of CT value of cervical vertebrae **a** Localization was performed by CT sagittal reconstruction of cervical spine **b** CT values were measured on the mid-transverse section **Figure 2** **a** The heights of the anterior and posterior edges of the fusion segment were measured on neutral lateral radiograph of cervical spine. ab was the height of the anterior edge, cd was the height of the posterior edge, and ef was the sagittal diameter of C1 **b** The Cobb angle of the fusion segment was measured on neutral lateral radiograph of cervical spine

发生沉降 184 例，两组患者基本情况见表 1。ACDF 术式中有 75 例发生沉降，发生率为 35.7%；ACCF 术式中有 37 例发生沉降，发生率为 67.3%；Zero-P 术式中有 10 例发生沉降，发生率为 24.4%(表 2)。

2.2 相关性分析

C2~C7 椎体 CT 均值与腰椎骨密度 T 值呈显著正相关性(r=0.518，P<0.001)。

C2~C7 椎体 CT 均值与融合节段 Cobb 角改变有显著相关性(r=-0.170，P=0.003)，呈负相关。但腰椎骨密度 T 值与融合节段 Cobb 角改变无显著相关性(P=0.605)。融合节段高度丢失值与 C2~C7 椎体 CT 均值无显著相关性(P=0.056)，与腰椎骨密度 T 值无显著相关性(P=0.274，表 3)。采用 Logistic 回归模型，控制性别、术式和节段的影响后，沉降(≥2mm)与 C2~C7 椎体 CT 均值有显著相关性(P=0.035，表 4)，C2~C7 椎体 CT 均值每升高1HU，沉降风险降低 0.4%(OR=0.996，95%CI：0.992~1.000)；控制性别、术式和节段的影响后，沉降（≥2mm）与腰椎骨密度 T 值无显著相关性(P=0.098，表 5)。以高度丢失≥2mm 为沉降，采用 C2~C7椎体CT 均值预测沉降的 ROC 曲线下面积为 0.562，C2~C7椎体CT 均值临界值为 273HU。

3 讨论

目前评估骨密度的金标准为基于 DXA 测量的 T 值。在既往的研究中我们发现，颈椎椎体 CT 值有助于颈椎手术患者术前骨密度临床评估[2]。其他研究显示，患者的骨密度异常与颈椎前路融合术后内置物沉降等并发症高度相关[1,5,6]。术前通过哪种骨密度的评估方法能够更加有效预测颈椎前路融合术后内置物沉降尚无共识。内置物沉降是颈椎前路手术常见的并发症，可导致颈部疼痛、内置物移位、假关节形成、后凸畸形等，严重者

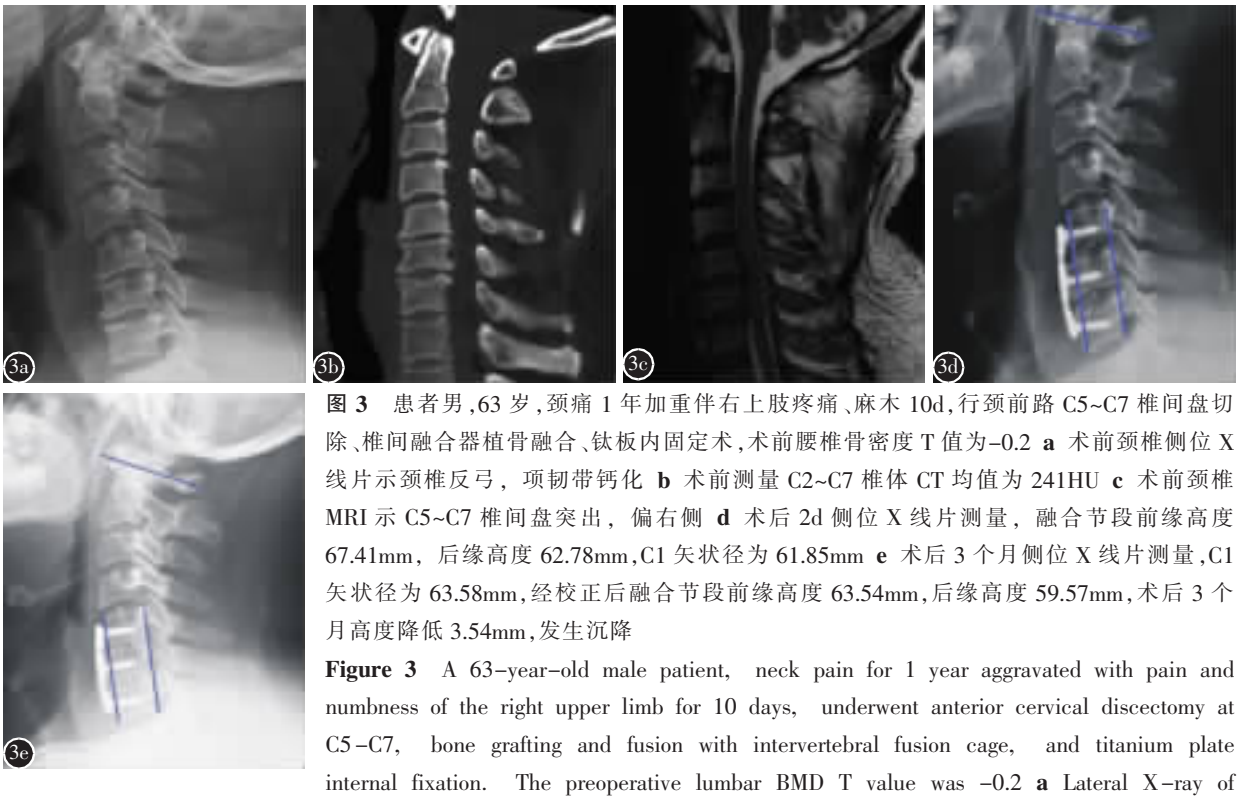

图 3 患者男，63 岁，颈痛 1 年加重伴右上肢疼痛、麻木 10d，行颈前路 C5~C7 椎间盘切除、椎间融合器植骨融合、钛板内固定术，术前腰椎骨密度 T 值为-0.2 **a** 术前颈椎侧位 X 线片示颈椎反弓，项韧带钙化 **b** 术前测量 C2~C7 椎体 CT 均值为 241HU **c** 术前颈椎 MRI 示 C5~C7 椎间盘突出，偏右侧 **d** 术后 2d 侧位 X 线片测量，融合节段前缘高度 67.41mm，后缘高度 62.78mm，C1 矢状径为 61.85mm **e** 术后 3 个月侧位 X 线片测量，C1 矢状径为 63.58mm，经校正后融合节段前缘高度 63.54mm，后缘高度 59.57mm，术后 3 个月高度降低 3.54mm，发生沉降

Figure 3 A 63-year-old male patient, neck pain for 1 year aggravated with pain and numbness of the right upper limb for 10 days, underwent anterior cervical discectomy at C5-C7, bone grafting and fusion with intervertebral fusion cage, and titanium plate internal fixation. The preoperative lumbar BMD T value was -0.2 **a** Lateral X-ray of cervical spine before operation showed retroflexion and calcification of the nuchal ligament **b** The C2-C7 CT mean value measured before operation was 241HU **c** Preoperative cervical MRI showed C5-C7 disc herniation, the right side **d** The height of the anterior edge of the fusion segment was 67.41mm, the height of the posterior edge was 62.78mm, and the sagittal diameter of C1 was 61.85mm measured on lateral X-ray on day 2 after operation **e** Three months after operation, the sagittal diameter of C1 was 63.58mm, the height of the anterior edge of the fusion segment was 63.54mm and the height of the posterior edge was 59.57mm after correction measured on lateral X-ray. The height decreased by 3.54mm and subsidence occurred at 3 months after operation

可引起内置物失效、脊髓压迫需要翻修手术等严重并发症。目前大部分研究认为内置物沉降与最终手术效果无明显相关性[7,8];但也有报道术后因内置物沉降导致椎间孔狭窄,导致神经刺激症状,从而进行翻修手术[9]。本研究旨在通过比较经典骨密度评估方法与颈椎椎体 CT 值在预测颈椎前路融合术后早期内置物沉降的敏感性,进一步探讨颈椎椎体 CT 值在预测颈椎前路融合手术术后内置物沉降的临床应用价值。

3.1 沉降的定义及发生率

颈椎前路融合术后随访过程中可以看到融合节段不同程度的高度丢失,既往文献中有的将发生沉降定义为融合节段高度丢失超过 3mm[6,9,10],有的定义为融合节段高度丢失超过 2mm[3,4]。定义沉降为高度丢失超过 3mm 的文献大多是采用仅使用椎间融合器而未同时行钛板固定的颈前路手术方式[9,10],而前路钛板固定有助于降低术后内置物沉降发生率[3],故本研究中将≥2mm 作为沉降发生的判断标准。

内置物沉降在术后早期即可发生。有研究认为,ACDF 与 ACCF 术后 Cobb 角减小、内置物沉降主要发生在术后 2 个月内[11]。另有研究认为,发生沉降最明显的时期为术后 3 个月左右[7,10,12,13],椎间融合后沉降停止。因此,本研究选取术后第二天及术后 3 个月复查的 X 线片进行对比分析。

表 1 沉降组及无沉降组患者的一般资料

Table 1 General information of patients in subsidence group and non-subsidence group

	沉降组 Group of subsidence	无沉降组 Group of non-subsidence
病例数 Number of cases	122	184
年龄(岁)* Age(years)	60.0(54.0~63.0)	58.0(53.0~62.0)
性别[男,例(%)] Gender[male, *n*(%)]	63(51.6)	59(32.1)
BMI(kg/m^2)	25.5±2.8	24.5±3.0
术式[*n*,(%)] Operation style		
ACDF	75(61.5)	135(73.4)
ACCF	37(30.3)	18(9.8)
Zero-P	10(8.2)	31(16.8)
节段[例,(%)] Segment		
单节段 Single segment	38(31.1)	91(49.5)
双节段 Double segments	59(48.4)	73(39.7)
三节段及以上 Three segments and above	25(20.5)	20(10.9)
C2~C7 椎体 CT 均值(HU)* C2-C7 CT mean value*	293.9 (248.0~360.3)	309.5 (277.7~354.7)
腰椎骨密度 T 值 Lumbar T value	−1.2±1.4	−1.0±1.3

注:*,年龄、C2~C7 CT 均值不符合正态分布,采用中位数(四分位数)展示,其余结果采用均数±标准差或百分比展示

Note: *, age and C2-C7 CT mean value did not conform to the normal distribution, which were displayed by the median (quartile), and the other results were displayed by the mean ± standard deviation or percentage

表 2 颈椎前路术式及沉降发生率

Table 2 Operation style of anterior cervical surgery and the incidence of subsidence

术式 Operation style	病例数 Number of cases	沉降例数 Cases of subsidence	沉降发生率(%) Incidence of subsidence
ACDF			
单节段 Single segment	58	8	13.8
双节段 Double segments	110	43	39.1
三节段 Three segments	41	23	56.1
四节段 Four segments	1	1	100.0
ACCF			
单节段 Single segment	45	30	66.7
双节段 Double segments	10	7	70.0
Zero-P			
单节段 Single segment	33	5	15.1
双节段 Double segments	6	3	50.0
三节段 Three segments	2	2	100
合计 Total	306	122	39.9

表 3 Spearman 秩相关检验结果

Table 3 Results of the Spearman rank correlation test

	*r*值 *r* value	*P*值 *P* value
C2~C7 CT 均值与腰椎骨密度 T 值 C2-C7 CT mean value and lumbar T value	0.518	<0.001
C2~C7 CT 均值与融合节段 Cobb 角改变 C2-C7 CT mean value and the change of Cobb angle of the fusion segment	−0.170	0.003
C2~C7 CT 均值与融合节段高度丢失值 C2-C7 CT mean value and the fusion segment height loss	−0.109	0.056
腰椎骨密度 T 值与融合节段 Cobb 角改变 Lumbar T value and the change of Cobb angle of the fusion segment	0.030	0.605
腰椎骨密度 T 值与融合节段高度丢失值 Lumbar T value and the fusion segment height loss	−0.063	0.274

本研究中将 ACDF 与 Zero-P 术式分开进行研究是因为,ACDF 术式中钛板能较好支撑椎间隙,能有效维持椎间高度及颈椎曲度;而 Zero-P 术式无钛板支撑，更易发生椎间融合器沉降及颈椎曲度改变。既往研究中颈椎前路 Zero-P 术式虽能获得与前路钛板系统固定相似疗效，但术后椎间隙高度丢失以及继发颈椎曲度改变均大于 ACDF[14]。Lee 等[15]认为 Zero-P 术式与 ACDF 疗效相似，但前者在椎间融合器沉降及椎间融合率方面均不及后者。

3.2 颈椎椎体 CT 值与术后早期 Cobb 角改变的关系

以往研究认为颈椎前路融合术治疗退行性疾病后，颈椎整体和融合节段的后凸改变是促进相邻椎间盘退行性改变的因素之一[16]。在临床工作中发现随着内置物沉降，颈椎曲度会发生继发性改变。本研究结果显示,术后 3 个月随访时,融合节段均出现不同程度后凸改变，且 C2~C7 椎体 CT 均值与融合节段 Cobb 角改变有显著负相关性，而腰椎骨密度 T 值与融合节段 Cobb 角改变无显著相关性。本研究结果提示,颈椎椎体 CT 值越高，术后早期颈椎前凸越容易保持；颈椎椎体 CT 值越低,术后早期越容易出现后凸畸形。因此对于预测术后早期因内置物沉降所导致的融合节段后凸改变，颈椎椎体 CT 值优于腰椎骨密度 T 值。

3.3 颈椎椎体 CT 值测量在预测颈前路融合术后内置物沉降的临床应用价值

影响颈椎前路融合术后内置物沉降的因素较多,包括手术操作因素,如术中对终板的破坏[3]、融合器的位置[17]等;患者自身因素,如年龄[18]、术前颈椎曲度[19]等;且亦与不同的手术方式有关,同节段数的 ACCF 较 ACDF 更易发生沉降[11,20,21]。在临床工作中，我们发现多节段融合比单节段融合更易发生沉降,本研究也证实这一情况,同样的手术方式,融合节段越多,沉降的发生率越高。

表 4 多因素 Logistic 回归模型中沉降（≥2mm）与性别、术式和节段及 C2~C7 椎体 CT 均值的相关性

Table 4 The correlations between subsidence (≥2mm) and gender, operation style and segment, and C2-C7 CT mean value in multivariate Logistic regression

	比值比(95%可信区间) Odds ratio (95% confidence interval)	*P*值 *P* value
性别 Gender		
女 Female	1.00	
男 Male	2.744(1.608~4.682)	<0.001
术式和节段 Operation style and segment		
ACDF 或 Zero-P 单节段 ACDF or Zero-P single segment	1.00	
ACDF 或 Zero-P 双节段 ACDF or Zero-P double segments	4.328(2.121~8.833)	<0.001
ACDF 或 Zero-P 三节段及以上 ACDF or Zero-P three segments and above	8.253(3.504~19.439)	<0.001
ACCF 单节段 ACCF single segment	12.313(4.875~31.098)	<0.001
ACCF 双节段 ACCF double segments	14.199(4.138~48.720)	<0.001
C2~C7 椎体 CT 均值 * C2-C7 CT mean value	0.996(0.992~1.000)*	0.035*

注:*,控制性别、术式和节段的影响后,沉降(≥2mm)与 C2~C7 椎体 CT 均值的相关性有统计学意义

Note: *, after adjusting gender, operation style and segment, the correlation between the subsidence(≥2mm) and the C2-C7 CT mean value was statistically significant

表 5 多因素 Logistic 回归模型中沉降(≥2mm)与性别、术式和节段及腰椎骨密度 T 值的相关性

Table 5 The correlations between subsidence (≥2mm) and gender, operation style and segment, and lumbar T value in multivariate Logistic regression

	OR(95%可信区间) OR(95% confidence interval)	*P*值 *P* value
性别 Gender		
女 Female	1.00	
男 Male	2.740(1.603~4.685)	<0.001
术式和节段 Operation style and segment		
ACDF 或 Zero-P 单节段 ACDF or Zero-P single segment	1.00	
ACDF 或 Zero-P 双节段 ACDF or Zero-P double segments	4.166(2.043~8.496)	<0.001
ACDF 或 Zero-P 三节段及以上 ACDF or Zero-P three segments and above	7.732(3.289~18.177)	<0.001
ACCF 单节段 ACCF single segment	12.417(4.928~31.286)	<0.001
ACCF 双节段 ACCF double segments	14.724(4.308~50.324)	<0.001
腰椎骨密度 T 值 * Lumbar T value*	0.844(0.690~1.032)*	0.098*

注:*,控制性别、术式和节段的影响后,沉降(≥2mm)与腰椎骨密度 T 值的相关性无统计学意义

Note: *, after adjusting gender, operation style and segment, the correlation between the subsidence and the lumbar T value was not statistically significant

目前临床普遍认为颈椎骨密度与颈前路术后内置物沉降明确相关，因此术前颈椎骨密度的评估对降低颈前路术后内置物沉降发生率非常重要。近期一项临床研究针对 235 例单节段和双节段 ACDF 手术患者术前不同骨密度评估方法进行比较，结果发现颈椎椎体 CT 值与基于 DXA 获得的 T 值之间的相关性具有统计学意义，因此，术前颈椎椎体 CT 值的测量是评估骨密度的可靠方法[22]。另一项研究针对 91 例行单节段 ACDF 手术患者的临床研究发现，术前较低的颈椎椎体 CT 值与单节段 ACDF 术后内置物沉降发生有关[4]。

本研究中 C2~C7 椎体 CT 均值与是否发生沉降的相关性无统计学意义，但在控制性别、术式和节段的影响后，C2~C7 椎体 CT 均值与是否发生沉降的相关性有统计学意义，CT 值每升高 1HU，沉降风险降低 0.4%。而腰椎骨密度 T 值在控制性别、术式及节段等重要影响因素后，与是否发生沉降的相关性仍无统计学意义。因此认为术前测量的颈椎椎体 CT 值相比腰椎骨密度 T 值能更好地预测颈椎前路融合术后内置物沉降。

本研究团队既往比照 WHO 诊断标准 [23]，提出了基于腰椎和颈椎椎体 CT 值的骨质疏松量化诊断参考[2,24]。此外，有研究指出，术前腰椎融合节段 CT 值是术后内置物发生沉降的独立危险因素，135.02HU 是预测沉降发生的参考阈值[25]。

本研究中以融合节段高度丢失≥2mm 作为术后发生内置物沉降的判断标准，通过 ROC 曲线分析，结果显示术前 C2~C7 椎体 CT 均值的临界值为 273HU。与之前研究中颈椎椎体 CT 值诊断骨质疏松的临界值 269HU[2]接近。因为颈椎椎体 CT 值为从头端向尾端逐渐下降，C6、C7 椎体 CT 值下降明显，所以认为如果术前 C6、C7 椎体 CT 值低于 273HU，术后发生沉降几率较大[2]。因此认为，当术前测量的 C2~C7 椎体 CT 均值接近骨质疏松的诊断标准时，术后更易发生沉降，CT 值每升高 1HU，沉降风险降低 0.4%。术前应重点交代术后内置物沉降风险较高，尤其是多节段前路手术，发生沉降几率较大，应该考虑是否可以改为后路手术。

3.4 研究局限性

本研究尚存在以下不足：(1)本研究为回顾性研究，沉降为作者在 PACS 系统上手工测量，且高度丢失一般为 0~3mm，虽然进行了校正，但仍有可能存在误差。相比而言，测量 Cobb 角可能更加精确。(2)ACDF 与 ACCF 的内置物生物力学应力环境不同，并且每种术式又分为不同融合节段数。因此，这些因素可能对最终研究结果也有影响。今后研究中应该设计分层的大样本、前瞻性研究。

综上所述，预测颈椎前路融合术后早期内置物沉降时颈椎椎体 CT 值要优于腰椎骨密度 T 值，术前较高的颈椎椎体 CT 值患者术后发生内置物沉降的风险较低。

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