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Clinical use of quantitative computed tomography to evaluate the effect of less paraspinal muscle damage on bone mineral density changes after lumbar interbody fusion

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Study Design: A retrospective cohort study.
Purpose: This study aimed to assess the reliability of quantitative computed tomography (QCT) in measuring bone mineral density (BMD) of instrumented vertebrae and investigate the effect of less paraspinal muscle damage on BMD changes after lumbar interbody fusion.
Overview of Literature: Patients always experience a decrease in vertebral BMD after lumbar interbody fusion. However, to the best of our knowledge, no study has analyzed the effect of paraspinal muscles on BMD changes.
Methods: This retrospective analysis included a total of 155 patients who underwent single-level lumbar fusion, with 81 patients in the traditional group and 74 patients in the Wiltse group (less paraspinal muscle damage). QCT was used to measure the volumetric BMD (vBMD), Hounsfield unit value, and cross-sectional area of the paraspinal muscles at the upper instrumented vertebrae (UIV), vertebrae one segment above the UIV (UIV+1), and the vertebrae one segment above the UIV+1 (UIV+2). Statistical analyses were performed.
Results: No significant differences in general data were observed between the two groups (p>0.05). Strong correlations were noted between the preoperative and 1-week postoperative vBMD of each segment (p<0.01), with no significant difference between the two time points in both groups (p>0.05). Vertebral BMD loss was significantly higher in UIV+1 and UIV+2 in the traditional group than in the Wiltse group (–13.6%±19.1% vs. –4.2%±16.5%, –10.8%±20.3% vs. –0.9%±37.0%; p<0.05). However, no statistically significant difference was observed in the percent vBMD changes in the UIV segment between the two groups (37.7%±70.1% vs. 36.1%±78.7%, p>0.05).
Conclusions: QCT can reliably determine BMD in the instrumented spine after lumbar interbody fusion. With QCT, we found that reducing paraspinal muscle destruction through the Wiltse approach during surgery can help preserve the adjacent vertebral BMD; however, it does not help increase the BMD in the instrumented vertebrae.

Keywords: Lumbar vertebrae; Bone mineral density; Lumbar interbody fusion; Paraspinal muscles; Quantitative computed tomography

Introduction

At present, interbody fusion is common in cases of disk herniation and stenosis in the presence of instability. Patients frequently experience a decrease in bone mineral density (BMD) in the adjacent vertebrae after lumbar interbody fusion for inflammation resulting from surgical trauma, stress shielding, and redistribution of loading [1-3]. Demir et al. [4] also found that the Hounsfield unit (HU) values of the vertebrae in stabilized segments consistently decreased postoperatively. Patients with low BMD are at risk of complications such as vertebral compression fractures, cage subsidence, and screw loosening [5-7]. Therefore, accurate measurement of vertebral BMD is important in patients who have undergone instrumented spinal fusion for the timely diagnosis of osteoporosis and provision of medical treatment. However, precise measurement of the BMD of the instrumented vertebrae remains difficult. Dual-energy X-ray absorptiometry is the most commonly used method for assessing BMD. However, it cannot differentiate between cortical and cancellous bones, and the presence of internal fixations and common degenerative changes (e.g., subchondral sclerosis, osteophyte formation, and calcification) can affect the accuracy of measurements [8]. In addition, the accuracy of lumbar BMD assessment using the HU value is still debated because the HU value provides a simplified representation of BMD [9]. Quantitative computed tomography (QCT) offers a potential solution for measuring the BMD of the instrumented vertebrae. Similar to conventional CT, QCT can obtain the HU value and cross-sectional area (CSA) of the paraspinal muscle, which has been proven reliable for assessing paraspinal muscle quality and measuring the muscle area [10]. This technique may also prove valuable in assessing the BMD of instrumented vertebrae commensurate with uninstrumented levels, using an appropriate region of interest (ROI). Meanwhile, it may help to identify the factors that preserve BMD after surgery.

Moreover, whether the paraspinal muscles offer protection against a decrease in BMD after spinal fusion surgery remains unclear. Studies have consistently demonstrated a significant correlation between lumbar BMD and paraspinal muscles [11,12]. A study conducted on rats revealed that preserving the muscle tissue surrounding the lumbar spine during surgical procedures may help prevent loss of bone quality and mass in adjacent areas [13]. Therefore, we hypothesized that reducing intraoperative paraspinal muscle destruction may play an important role in preserving the BMD in patients who have undergone lumbar interbody fusion. In clinical practice, the traditional and Wiltse approaches are commonly used in lumbar interbody fusion surgeries. However, compared with the Wiltse approach, the traditional approach often results in more damage, greater atrophy, and fatty infiltration of the lumbar paraspinal muscles, particularly the multifidus muscle [14,15]. Differences may be observed in postoperative BMD changes between different approaches, and these differences should be considered during the clinician's preoperative surgical planning and selection of surgical approaches for better BMD.

Thus, this study aimed (1) to assess the accuracy of QCT in measuring the BMD of the instrumented vertebrae after lumbar interbody fusion and (2) to investigate the effect of less paraspinal muscle damage on BMD changes after lumbar interbody fusion.

Materials and Methods

Patient enrollment

This study conducted a retrospective analysis of the medical records of patients who underwent single-segment lumbar fusion between February 2015 and July 2022. This study was conducted in compliance with the principles of the Declaration of Helsinki. The study protocol was reviewed and approved by the Medical Ethics Committee of Shenzhen People's Hospital (approval no., LL-KY-2023003-01). Written informed consent was obtained from all the patients.

The inclusion criteria were as follows: (1) single-segment lumbar interbody fusion performed at the L4/5 or L5/S1 level; and (2) traditional or Wiltse approach performed for the surgery. The exclusion criteria were as follows: (1) other lumbar surgeries; (2) other spine diseases such as severe spinal deformity, spinal or spinal cord trauma, spinal infection, spinal tumors, or ankylosing spondylitis; (3) a history of abnormal bone metabolism; (4) intake of glucocorticoids, heparin, antiosteoporotic medication, or other drugs that may affect bone metabolism before the surgery; (5) a long period of bedriddenness after the surgery; and (6) <1 year of follow-up.

Based on these criteria, 155 patients were included in the follow-up analysis, with 81 patients in the traditional group and 74 patients in the Wiltse group (less paraspinal muscle damage). The patients included in the study underwent surgery performed by the same surgeon.

Measurement parameters

The computed tomography (CT) scanning conditions were as follows: voltage, 140 kV; current, 250 mA; slice thickness, 1.5 mm; field of view, 170 mm; and scanning range, L1 to S1. After scanning, the CT images were transferred to the QCT software (Brilliance 16; Philips, Amsterdam, The Netherlands) for analysis. Measurements of volumetric BMD (vBMD), HU value, and CSA were performed using the software by the same experienced observer. Two measurements were recorded. To evaluate interobserver variability, a second observer remeasured the images of all patients. The measurements were blinded and independently conducted by the observers.

To measure the vBMD of the upper instrumented vertebrae (UIV), the first axial cut caudad to the halo generated by the instrumentation was used, and the ROI was drawn on the postoperative CT scan. For the vBMD measurements of the vertebrae, one segment above the UIV (UIV+1) and one segment above the UIV+1 (UIV+2), the ROI was drawn on axial cuts at the mid-pedicle, encompassing the maximal cancellous bone volume while avoiding the cortical bone in the postoperative CT scan. Care was taken to perform axial cuts at the same location on preoperative and final follow-up images. QCT software generated an average vBMD measurement of the ROI.

To measure the HU value and CSA of the paraspinal muscles, the ROI was manually traced along the fascial boundary of the psoas major and multifidus and erector spinae on both sides of the spinal column: ROI was drawn on axial cuts at the mid-pedicle of UIV, UIV+1, and UIV+2 on the preoperative CT scan. The QCT software generated the HU values and CSA measurements of the ROI. The HU value of each muscle was

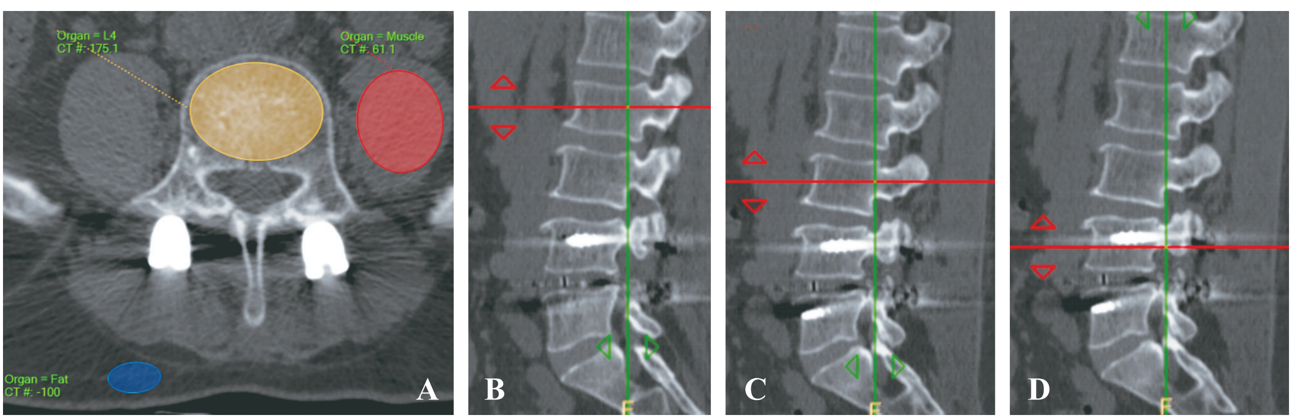

Fig. 1. Measurements of the postoperative volumetric bone mineral density (vBMD). **(A)** The region of interest (ROI) was drawn on axial cuts encompassing the maximal cancellous bone volume while avoiding cortical bone in the postoperative CT scan. **(B–D)** The level of axial cut for measurements of vBMD in postoperative sagittal image.

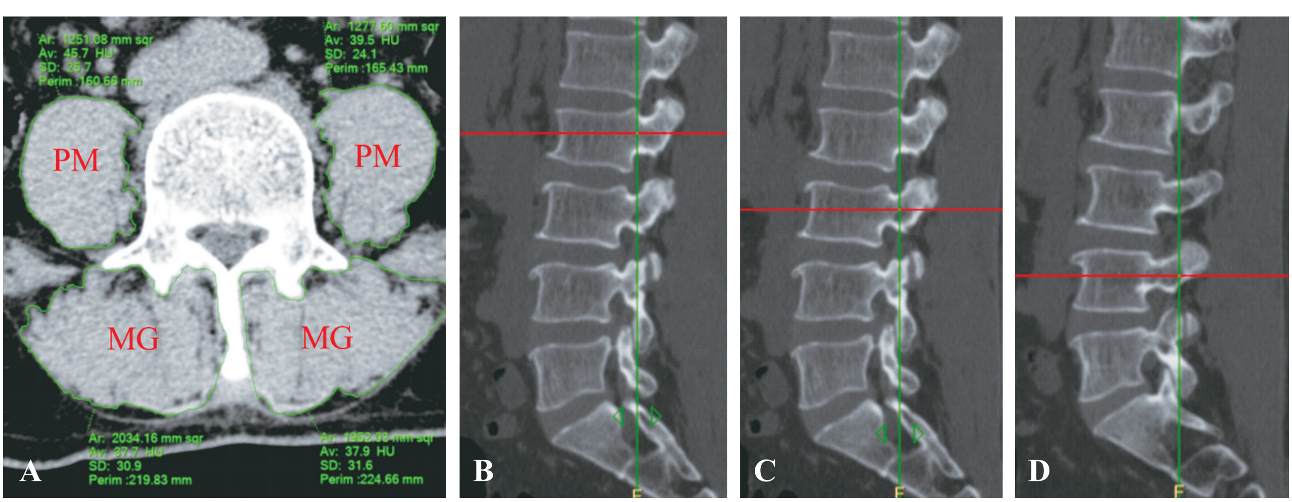

Fig. 2. Measurements of Hounsfield unit (HU) value and cross-sectional area (CSA) of the paravertebral muscles. **(A)** The region of interest (ROI) was manually traced along the fascial boundary of the above muscles on both sides of the spinal column on axial cuts: psoas major (PM) and multifidus and erector spinae (MG). **(B–D)** The level of axial cut for measurements of HU value and CSA of the paravertebral muscles in preoperative sagittal image.

determined by averaging the corresponding HU values of the left and right sides, and the CSA of each muscle was determined by summing the corresponding CSA values of the left and right sides (Figs. 1, 2).

Surgical technique

In the Wiltse group, a longitudinal incision was made through the skin and the subcutaneous tissue. The lumbodorsal fascia was opened 2–3 cm laterally parallel to the midline. The approach is performed between the multifidus and longissimus muscles, allowing exposure of the facet joints and roots of the transverse process through blunt dissection. On the contrary, the muscles were separated along the supraspinous ligament.

In the traditional group, an incision was made at the midline of the back. The bilateral muscles were then separated along both sides of the supraspinous ligament to expose the spinous process, facet joints, root of the transverse process, and the bilateral lamina of the affected segments.

In both groups, screws were implanted at the intersection of the lateral facet of the articular process and root of the transverse process. Laminectomy and discectomy procedures were performed to decompress the spinal canal and nerve roots. The cartilage endplates and disks were removed to achieve an optimal bone–bone surface, which is crucial for successful spinal fusion. After preparation of the endplates, the bone tissues were inserted into a suitably sized cage, which was then placed into the intervertebral space. Finally, the surgical site was irrigated and closed layer-by-layer.

Complications

BMD-associated complications after lumbar interbody fusion surgery include adjacent segment disease (ASD), screw loosening, and screw pullout. They were all documented at the final follow-up. ASD was defined as a condition in which a patient showed symptom alleviation for at least 3 months after the index operation, and the development of new clinical symptoms was compatible with radiographic changes at adjacent segments. A halo sign on the CT image showing a radiolucent rim surrounding the screw encircled by dense bone trabeculae can be identified as screw loosening.

Statistical analysis

Statistical processing of the measured data was performed using IBM SPSS Statistics for Windows ver. 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables that follow a normal distribution are presented as the mean±standard deviation. To compare the distributions of sex, UIV level, antiosteoporotic medication after surgery, disease types, and complications between the two groups, chi-square tests were employed. Independent sample *t*-tests and paired *t*-tests were used to analyze differences between and within the two groups. Statistical significance levels were set at $p<0.05$ for all comparisons. The intraclass correlation coefficients (ICCs) of the intra- and interobserver reliability for the measurements of vBMD, HU values, and CSA were calculated, and the significance levels were set at $p<0.05$. ICCs of 0.75–0.90 indicated good agreement, whereas ICCs of >0.90 indicated excellent agreement. Pearson correlation coefficients were used to analyze the correlations between vBMD before surgery and 1 week after surgery. Statistical significance levels were set at $p<0.01$. Correlation coefficients were interpreted as strong (0.70–0.90) or extremely strong (0.90–1.00).

Results

Patients and clinical characteristics

In this study, 155 patients were enrolled and divided into the traditional (n=81) and Wiltse groups (n=74). The patient demographics are presented in Table 1. The follow-up time was 16.2±7.7 months in the traditional group and 15.8±10.2 months in the Wiltse group, and the difference between them was not statistically significant ($p>0.05$). No significant differences in sex, age, UIV level, body mass index, antiosteoporotic medication after surgery, disease types, preoperative HU values, or CSA of the paraspinal muscles were found between the two groups ($p>0.05$). The intra- and interobserver agreements of vBMD, HU values, and CSA measurements were good to excellent (Table 2).

Preoperative and 1-week postoperative vBMD in the traditional and Wiltse groups

In the traditional group, extremely strong correlations were observed between preoperative and 1-week postoperative vBMD for the UIV+2, UIV+1, and UIV segments (coefficients=0.957, 0.970, and 0.967; $p<0.01$). In the Wiltse group, extremely strong and strong correlations were found between the preoperative and 1-week postoperative vBMD of the UIV+2, UIV+1, and UIV segments (coefficients=0.952, 0.962, and 0.877; $p<0.01$) (Table 3). In both groups, no statistically significant differences were observed between the preoperative and 1-week postoperative vertebral vBMD of each segment (p>0.05) (Table 4).

Percent vBMD changes in each segment of the two groups

At the final follow-up, within the traditional group, the vBMD of the UIV segment demonstrated an increase compared with the measurement taken 1 week postoperatively, with a percentage vBMD change of 37.7%±70.1% (p<0.05). Conversely, the vBMD of the UIV+1 and UIV+2 segments decreased, with percent vBMD changes of −13.6%±19.1% and −10.8%±20.3%, respectively (p<0.05). Similarly, in the Wiltse group, at the final follow-up, the vBMD of the UIV segment increased compared with that at 1 week postoperatively, showing a percent vBMD change of 36.1%±78.7%

Table 1. Comparison of demographic data between the traditional and Wiltse groups

Characteristic	Traditional group (n=81)	Wiltse group (n=74)	p-value
Follow-up duration (mo)	16.2±7.7	15.8±10.2	0.803
Sex			0.807[a)]
Male	40	38	
Female	41	36	
Age (yr)	55.7±12.7	56.6±12.0	0.631
UIV level			0.490[a)]
L4 level	71	62	
L5 level	10	12	
Body mass index (kg/m^2)	24.2±3.2	24.6±3.0	0.429
Anti-osteoporotic medication after surgery			0.629[a)]
Zoledronic acid	24	23	
Denosumab	5	2	
None	52	49	
Disease types			0.472[a)]
Lumbar spinal stenosis	44	44	
Lumbar spondylolisthesis	31	22	
Lumbar disc herniation	6	8	
Preoperative HU value of paravertebral muscles			
UIV+2 PM	41.3±10.8	39.1±13.0	0.254
UIV+2 MG	39.9±9.0	38.7±8.3	0.408
UIV+1 PM	45.2±8.5	44.4±8.8	0.560
UIV+1 MG	38.8±9.7	39.5±8.5	0.643
UIV PM	47.0±6.2	45.9±6.0	0.285
UIV MG	37.6±10.6	38.3±8.6	0.685
Preoperative CSA of paravertebral muscles (mm^2)			
UIV+2 PM	613.6±444.5	682.8±401.5	0.319
UIV+2 MG	3,165.8±870.8	3,357.0±680.4	0.110
UIV+1 PM	1,019.4±494.3	1,127.2±583.4	0.208
UIV+1 MG	3,329.7±885.9	3,388.4±753.6	0.663
UIV PM	1,381.1±598.4	1,509.4±700.8	0.216
UIV MG	3,281.3±1,685.8	3,087.4±761.3	0.384

Values are presented as mean±standard deviation or number.
UIV, upper instrumented vertebrae; HU, Hounsfield unit; UIV+1, the vertebrae one segment above the UIV; UIV+2, the vertebrae one segment above the UIV+1; PM, psoas major; MG, multifidus and erector spinae; CSA, cross-sectional area.
For calculation of each p-value in the table, [a)]chi-square test is used; the rest adopts two independent sample t-test.

Table 2. Inter- and intraobserver ICCs

Level	vBMD			Preoperative HU value of PM	Preoperative HU value of MG	Preoperative CSA of PM	Preoperative CSA of MG
	Preoperative	1 Week after surgery	Final follow-up				
Intraobserver ICC							
UIV+2	0.975[a)]	0.976[a)]	0.979[a)]	0.976[a)]	0.975[a)]	0.972[a)]	0.968[a)]
UIV+1	0.982[a)]	0.985[a)]	0.978[a)]	0.974[a)]	0.979[a)]	0.971[a)]	0.970[a)]
UIV	0.971[a)]	0.988[a)]	0.991[a)]	0.983[a)]	0.972[a)]	0.976[a)]	0.967[a)]
Interobserver ICC							
UIV+2	0.958[a)]	0.937[a)]	0.939[a)]	0.947[a)]	0.932[a)]	0.929[a)]	0.927[a)]
UIV+1	0.934[a)]	0.969[a)]	0.945[a)]	0.933[a)]	0.928[a)]	0.931[a)]	0.899[a)]
UIV	0.931[a)]	0.974[a)]	0.972[a)]	0.927[a)]	0.945[a)]	0.917[a)]	0.922[a)]

ICC, intraclass correlation coefficient; vBMD, volumetric bone mineral density; HU, Hounsfield unit; PM, psoas major; MG, multifidus and erector spinae; CSA, cross-sectional area; UIV, upper instrumented vertebrae; UIV+1, the vertebrae one segment above the UIV; UIV+2, the vertebrae one segment above the UIV+1.
[a)]Statistically significant.

Table 3. Correlations between preoperative and 1-week postoperative vBMD in traditional and Wiltse groups

Level	Traditional group		Wiltse group	
	Coefficient	*p*-value	Coefficient	*p*-value
UIV+2	0.957	0.000**	0.952	0.000**
UIV+1	0.970	0.000**	0.962	0.000**
UIV	0.967	0.000**	0.877	0.000**

The calculation of each *p*-value adopts Pearson correlations analysis.
vBMD, volumetric bone mineral density; UIV, upper instrumented vertebrae; UIV+1, the vertebrae one segment above the UIV; UIV+2, the vertebrae one segment above the UIV+1.
**p<0.01; statistically significant.

(p<0.05). Meanwhile, the vBMD of the UIV+1 and UIV+2 segments decreased compared with that at 1 week postoperatively, with percent vBMD changes of −4.2%±16.5% and −0.9%±37.0% (p<0.05). Moreover, at the final follow-up, a statistically significant difference was noted in the vertebral vBMD of the UIV+1 segment between the traditional and Wiltse groups (64.0±34.0 mg/cm^3 versus 74.5±31.5 mg/cm^3, p<0.05). Statistically significant differences were found in the percent vBMD changes in the UIV+1 and UIV+2 segments between the traditional and Wiltse groups (−13.6%±19.1% versus −4.2%±16.5%, −10.8%±20.3% versus −0.9%±37.0%; p<0.05). However, no statistically significant difference in the percent vBMD changes in the UIV segment was observed between the two groups (37.7%±70.1% versus 36.1%±78.7%, p>0.05) (Table 5).

Complications

At the last follow-up, two cases of ASD were observed in the traditional group, whereas one case of ASD occurred in the Wiltse group. In the traditional group, 10 instances of screw loosening, compared with seven cases in the Wiltse group, were recorded. No screw pullout was observed in either group at the last follow-up. Regarding complications, no statistically significant differences were found between the two groups (p>0.05) (Table 6).

Discussion

Literature validating the use of QCT BMD assessment in instrumented vertebrae is limited. In this study, we used the method described by Wanderman et al. [16] to measure vertebral BMD using QCT. The strong correlation and lack of statistically significant differences between pre- and postoperative BMD measurements indicated that QCT could provide reliable BMD values in the postoperative spine.

Screw loosening is a common complication after fusion surgery, and pullout strength is mostly affected by BMD [17]. Therefore, the BMD around the screw must be measured and preserved. The HU value is currently used for BMD evaluation. Demir et al. [4] used the HU value to evaluate the density of the instrumented vertebrae. However, they did not demonstrate whether the HU value could be used to bypass the confounding effects of metallic artifacts. Wanderman et al. [16] further proved this and revealed that the postoperative vertebral HU values, measured in the presence of internal fixation, were highly correlated with the preoperative HU values, and no statistical differences were noted between them. This finding allows for obtaining reliable postoperative BMD values in internally fixed vertebrae [16]. Although the HU value has been proven to correlate closely with the QCT-measured BMD

Table 4. Comparison between preoperative and 1-week postoperative vBMD in the traditional group and the Wiltse) group (mg/cm^3, $\bar{x}$±s)

Level	Traditional group		*p*-value	Wiltse group		*p*-value
	Preoperative	1 Week after surgery		Preoperative	1 Week after surgery	
UIV+2	76.5±33.8	77.7±34.6	0.303	78.4±29.8	79.8±31.4	0.197
UIV+1	71.2±33.6	72.0±33.8	0.356	77.5±29.9	77.7±30.1	0.803
UIV	85.4±46.0	86.4±46.0	0.439	82.4±31.0	84.5±37.3	0.341

Values are presented as mean±standard deviation. The calculation of each *p*-value adopts paired *t*-test.
vBMD, volumetric bone mineral density; UIV, upper instrumented vertebrae; UIV+1, the vertebrae one segment above the UIV; UIV+2, the vertebrae one segment above the UIV+1.

Table 5. The lumbar vBMD 1 week after surgery and at the last follow-up and vBMD changes in each level in the traditional group and the Wiltse group (mg/cm^3, $\bar{x}$±s)

Level	Group	1 Week after surgery	Final follow-up	vBMD change (%)	*p*-value[a)]
UIV+2	Traditional group	77.7±34.6	70.4±34.7	-10.8±20.3	0.000*
	Wiltse group	79.8±31.4	76.5±32.0	-0.9±37.0	0.047*
	p-value[b)]	0.687	0.259	0.038*	
UIV+1	Traditional group	72.0±33.8	64.0±34.0	-13.6±19.1	0.000*
	Wiltse group	77.7±30.1	74.5±31.5	-4.2±16.5	0.021*
	p-value[b)]	0.273	0.048*	0.001*	
UIV	Traditional group	86.4±46.0	110.2±60.3	37.7±70.1	0.000*
	Wiltse group	84.5±37.3	99.6±36.6	36.1±78.7	0.001*
	p-value[b)]	0.773	0.185	0.892	

Values are presented as mean±standard deviation.
vBMD, volumetric bone mineral density; UIV, upper instrumented vertebrae; UIV+1, the vertebrae one segment above the UIV; UIV+2, the vertebrae one segment above the UIV+1.
*$p<0.05$; statistically significant. The calculation of each [a)]*p*-value adopts paired *t*-test and [b)]*p*-value adopts two independent sample *t*-test.

Table 6. Complications at the last follow-up

Complication	Traditional group	Wiltse group	*p*-value
Adjacent segment disease	2 (2.5)	1 (1.4)	1.000
Screw loosening	10 (12.3)	7 (9.5)	0.566
Screw pullout	0	0	

Values are presented as number (%). The calculation of each *p*-value adopts chi-square test.

value [18], it provides a simplified representation of the BMD [9]. A more accurate BMD result can be obtained using QCT, which converts the HU value of the scanned image to hydroxyapatite equivalent density.

Based on the QCT-measured BMD, the researchers compared the vertebral vBMD at 1 week after lumbar interbody fusion surgery with that at the last follow-up. We observed that the vBMD of the instrumented vertebrae increased in both the traditional and Wiltse groups during an average follow-up of approximately 16 months. On the contrary, the vBMD of adjacent vertebrae decreased. This trend in postoperative BMD changes was consistent between both groups.

Several studies have investigated BMD reduction in adjacent vertebrae after spinal fusion surgery. For instance, Balci et al. [19] demonstrated a decrease in vertebral body BMD at adjacent levels without screw fixation at an average 9-month follow-up in patients aged 18–78 years, and this BMD loss persisted. Wanderman et al. [16] also observed a statistically significant decrease in HU value in nonfixed segments over 1 year. Okano et al. [20] found a decrease in vBMD in the UIV+1 and UIV+2 segments in patients aged 25–89 years during a follow-up period of 6–12 months, suggesting that surgically induced inflammation contributes to postoperative bone loss. However, the literature on long-term changes in the BMD of instrumented segments is limited. Demir et al. [4] found that the HU values of stabilized segments consistently decreased after surgery. This is in contrast with our results. However, their study comprised only 16 patients with L2–3–4–5 transpedicular screw fixation and had limited follow-up, which could have resulted in differences between the two studies. Easley et al. [21] used an ovine lumbar spine model and indicated an increase in BMD around the screws early after the fusion procedure, as evidenced by a higher screw pullout force at 6 months compared with baseline, although statistical significance was not described in the study. Studies related to hip and knee replacements have shown an increase in the BMD of the bone surrounding the implant [22,23]. Based on these findings, the researchers hypothesized that the increase in the BMD of the instrumented segments may be attributed to the stimulation of cancellous bone by metal implants, which inhibits bone resorption and promotes bone augmentation. Furthermore, pronounced bone proliferation and sclerosis were observed in the vertebral portion, adjacent to the fusion device. Therefore, the increased BMD in the instrumented segment may be attributed to intraoperative removal of the cartilage endplate, exposure of the bony endplate, and implantation of a fusion device containing autogenous bone, which facilitates bone formation in the UIV. However, further studies are required to confirm this hypothesis and gain a better understanding of the underlying mechanisms.

In this study, vBMD loss was significantly higher in UIV+1 and UIV+2 in the traditional group than in the Wiltse group, whereas no statistically significant difference was observed in the percentage vBMD changes of the UIV segment between the two groups. These findings suggested that reducing paraspinal muscle destruction during surgery could help preserve the adjacent vertebral BMD; however, it did not help increase BMD in the fixation segment.

The Wiltse approach primarily reduces damage to the paraspinal muscles at the surgical site and contributes to reducing postoperative atrophy and fat infiltration of the multifidus muscles next to the adjacent vertebrae [14,24]. Several studies have shown a strong association between fatty infiltration of the multifidus muscle and lumbar BMD [25,26]. Wang et al. [13] conducted an experimental study in rats and found that bone loss occurred in rats with paraspinal muscular atrophy compared with that in controls. They concluded that preserving the muscle tissue around the lumbar spine during clinical surgery was important to prevent the loss of lumbar spine bone quality and mass [13]. Jin et al. [27] found that skeletal muscle satellite cells that adhere to muscle fibers play a crucial role in the repair of osteoporotic fractures, maintaining their differentiation into osteoblasts and restricting osteoclastogenesis through the β-catenin signaling pathway. A previous study showed that the paraspinal muscles play an important role in promoting vascular growth into the fusion site and accelerating bone healing in white rabbits that underwent posterolateral spinal fusion [28]. In addition, patients who underwent fusion via the Wiltse approach can achieve a lower Visual Analog Scale score and Oswestry Disability Index than those who underwent fusion using the traditional approach [29], which allows them to be more physically active. BMD is affected by physical activities to a certain extent [30]. Therefore, intraoperative protection of the paraspinal muscles is important to preserve vertebral BMD, including the adjacent vertebral BMD. We suggest that surgeons perform lumbar interbody fusion using the Wiltse approach, particularly in patients with low BMD.

This study has some limitations. First, being a retrospective study, selective bias is possible. The study also lacked a standardized follow-up duration; therefore, the researchers used the average follow-up periods. Second, the measurements of paraspinal muscles would have been more accurate if magnetic resonance imaging was used. Third, the age range of the patients included was broad, ranging from 23 to 79 years. The BMD change after lumbar fusion may vary among patients of different age groups. However, subgroup analysis among different age groups could not be performed because of the small sample size. Fourth, no statistically significant difference in antiosteoporosis treatment was found between the two groups. However, we did not further evaluate the effect of different antiosteoporotic medications on BMD changes because of the small sample size. Therefore, future studies should include prospective randomized controlled trials with a larger sample size to validate the generalizability of the study results.

Conclusions

QCT can produce reliable BMD in the instrumented spine after lumbar interbody fusion. With QCT, we found that reducing paraspinal muscle destruction through the Wiltse approach during surgery can help preserve the BMD of the adjacent vertebrae; however, it does not help increase the BMD in the instrumented vertebrae. We suggest that surgeons perform lumbar interbody fusion via the Wiltse approach, particularly in patients with low BMD.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Author Contributions

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