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Original Article

Associations between the hounsfield unit values of different trajectories and bone mineral density of vertebrae: cortical bone and traditional trajectories

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Abstract: Cortical bone trajectory (CBT) is widely used in orthopedic surgery to improve fixation while minimizing soft tissue dissection. This study used radiological methods to assess the correlation between the bone mineral density (BMD) of vertebrae and Hounsfield unit (HU) values of CBT and traditional trajectory (TT). A total of 240 thoracic and lumbar (T9-L5) vertebrae from 40 cadaveric spines were obtained. The specimens were measured using computed tomography (CT). The axial CT images of TT were sliced in a plane horizontal to the pedicle, whereas those of CBT were sliced in a caudocranial plane. The regions of interest of TT and CBT were selected to calculate an average HU value within the area, wherein the screws were inserted and fixed at 6.0 mm × 40 mm and 4.0 mm × 30 mm, respectively. The BMD of vertebrae was measured by dual-energy X-ray absorptiometry (DEXA) and quantitative CT (QCT). The HU value of CBT (286.74 ± 120.80) was almost twice higher than that of TT (165.61 ± 92.38). The average lateral and anteroposterior BMDs of 240 vertebrae determined using DEXA were 0.540 ± 0.193 and 0.651 ± 0.180 g/cm^2, respectively. The average cortical and cancellous BMDs of 240 vertebrae determined using QCT were 245.63 ± 80.09 and 88.24 ± 61.78 mg/cm^3, respectively. The BMD determined using DEXA and QCT was significantly and positively associated with the HU values of CBT and TT. The ratio of the HU values of CBT and TT was significantly and negatively associated with the lateral BMD determined using DEXA and the cancellous BMD determined using QCT. However, it was significantly and positively associated with segments but not with the anteroposterior BMD determined using DEXA and the cortical BMD determined using QCT. Collectively, the HU values of CBT and TT significantly decreased with decreasing BMD. However, the CBT HU values significantly decreased less than the TT HU values, especially in low-BMD vertebrae and cauda lumbar segments.

Keywords: Cortical bone trajectory, hounsfield unit, traditional trajectory, DEXA, QCT, bone mineral density

Introduction

Osteoporosis has become a challenge to spinal surgeons performing pedicle screw instrumentation as screw loosening is a well-known complication due to loss of surgical construct stability, especially in patients with poor bone quality [1-4]. Low bone mineral density (BMD) is a clear risk factor that may compromise the mechanical performance of spinal implants because poor vertebral bone quality juxtaposed to pedicle screw results in compromised screw-bone interface strength [5-7]. In addition, the cancellous bone is more profoundly affected by osteoporosis than the cortical bone [2]. The cortical bone trajectory (CBT) has been proposed as an alternative method to increase screw-bone purchase of pedicle screws in spinal surgery. Altering the traditional trajectory (TT) leads to higher bone density [8] because the TT engages a greater portion of cancellous bone than cortical bone [7, 9]. Previous biomechanical studies have demonstrated that the novel CBT screw design has equivalent or better pullout and toggle characteristics compared with the TT [7-10]. The CBT follows a caudocephalad path on the sagittal plane and a laterally directed path on the transverse plane with

a theoretical advantage of increasing cortical bone contact, which may explain some of the results of biomechanical studies.

Currently, dual-energy X-ray absorptiometry (DEXA) and quantitative computed tomography (QCT) are used to measure vertebral bone density. DEXA is easy to perform, but its results can be influenced by lumbar scoliosis and degenerative changes [11, 12]. QCT, the gold standard for measuring bone density, can measure the density of cortical and cancellous bones. However, DEXA and QCT measure the vertebral body rather than the trajectory. The Hounsfield unit (HU) measurements from CT images are recommended by many studies for BMD assessment and bone strength estimation [13-15]. Moreover, the CT HU value and DEXA BMD are positively correlated [16]. Some radiological studies compared the average bone CT number (HU values) within the area wherein pedicle screws are normally placed for both trajectories and demonstrated that the HU values of CBT are substantially greater than those of TT [17-19]. However, the correlation between the BMD of vertebrae and the HU values of CBT and TT is yet to be examined. This association will be advantageous in applying the HU values of trajectory to estimate bone strength and predict pedicle screw stability, especially in medical institutions without QCT, and may avoid DEXA evaluation for some patients. Therefore, the present study used human cadaveric vertebrae from a radiological standpoint to assess whether the HU values of CBT and TT are correlated with the BMD of vertebrae, which was measured using DEXA and QCT scans.

Materials and methods

A total of 240 thoracic and lumbar vertebrae of 40 human spines (19 males and 21 females) were provided by the Department of Human Anatomy of Anhui Medical University. Previous studies, including our own morphometric study, have demonstrated the feasibility of applying CBT screws from T9 to L5 [18, 20]. However, traditional pedicle screw placement in the middle and upper thoracic segments is difficult as the pedicle in these segments is small. The key area of orthopedic stress concentration in the lower thoracic region and lumbar spine is also the area where screws tend to become loose. Therefore, T9-L5 was the selected segment. This research was approved by the institutional review board of the authors' affiliated institutions. Each vertebra was dissected free of soft tissue, and the osteophytes around the vertebral body were removed and reviewed using radiography and CT scanning (GE Discovery CT 750 HD) to ascertain no sign of trauma, scoliosis, kyphosis, tumors, or spinal surgery. Reformatted images with a thickness of 0.625 mm were obtained [21], and the scan parameters were set according to a previous study [18]. A region of interest (ROI) was selected using the axial slices of the specimen's vertebrae for each trajectory by applying the GE picture archiving and communication system (General Electric Medical Systems, Milwaukee, WI, USA) to calculate the average HU value [17, 22]. The axial CT images of the TT were sliced in a plane horizontal to the pedicle, whereas those of the CBT were sliced in a caudocranial plane. The starting point of the TT was set at the bisection of a vertical line through the facet joints and a horizontal line through the transverse process (**Figure 1A**), whereas that of the CBT was set at the junction of the center of the superior articular process and 1 mm inferior to the inferior border of the transverse process (**Figure 1B**). The ROI started at the entry point of the TT, and the CBT was directed toward the pedicle midline to represent the ideal area for screw insertion (**Figure 1C** and **1D**). Moreover, the ROIs of the TT and CBT were fixed at 6.0 mm × 40 mm and 4.0 mm × 30 mm, respectively, which represented the pedicle screws used in TT and CBT. Measurements were performed by two independent spine surgeons familiar with anatomy and screw insertion technique in the spine. The HU values of the right and left pedicles were measured thrice in each vertebra and averaged to give a mean HU value for each trajectory [18].

The DEXA (GE Medical Systems Lunar, lateral position and anteroposterior position) and QCT (SIEMENS SOMATOM Spirit) were used to measure the BMD of the specimens' vertebrae [23]. According to the QCT trabecular spine BMD range, the threshold value of the osteoporotic vertebrae was classified as normal (BMD > 120 mg/cm^3), osteopenia (80 mg/cm^3 ≤ BMD ≤ 120 mg/cm^3), and osteoporosis (BMD < 80 mg/cm^3) [23]. The threshold value of osteoporotic vertebrae was also defined as a BMD lower than 0.8 g/cm^2 or a T-score of -2.5 or less as measured through DEXA [24].

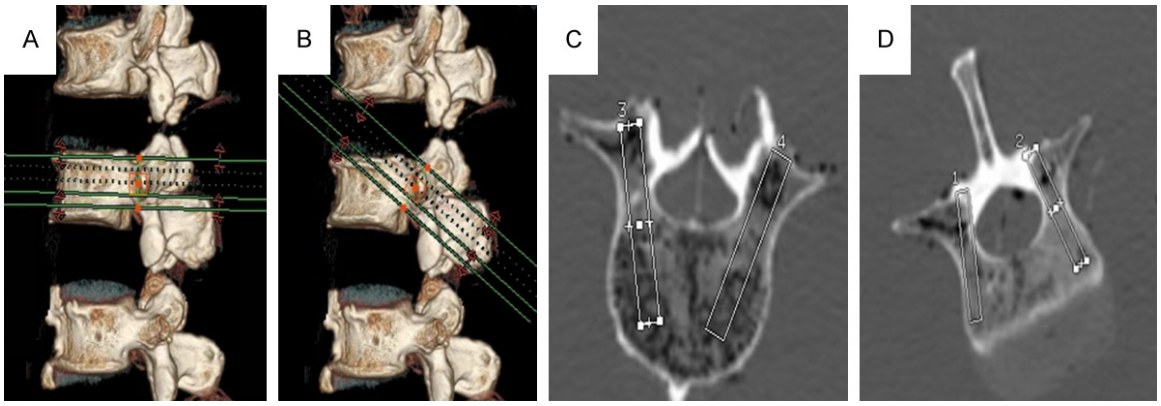

Figure 1. Sagittal thin-sliced CT images displaying the screw insertion angle for the TT (A) and CBT (B). The CT numbers of the TT (C) and CBT (D) calculated through ROI. CT, computed tomography; CBT, cortical bone trajectory; TT, traditional trajectory; ROI, region of interest.

Table 1. Baseline characteristics of all specimens

Characteristic	Donors* (n = 40)
Age (years)	68.7 (9.4)
Gender (Female/Male, %)	52.5/47.5
Height (cm)	160.8 (8.0)
Weight (kg)	60.9 (5.9)
CBT HU values	286.74 (120.80)
TT HU values	165.61 (92.38)
CBT HU/TT HU	2.00 (0.90)
BMD (DEXA, lateral position, g/cm^2)	0.540 (0.193)
≤ 0.8	0.497 (0.129)
> 0.8	0.990 (0.177)
BMD (DEXA, anteroposterior position, g/cm^2)	0.651 (0.180)
≤ 0.8	0.587 (0.104)
> 0.8	0.947 (0.160)
BMD (QCT, cortical bone, mg/cm^3)	245.63 (80.09)
BMD (QCT, cancellous bone, mg/cm^3)	88.24 (61.78)
< 80	51.41 (18.73)
80-120	93.72 (10.41)
> 120	172.59 (78.70)

*Data were presented as mean (SD) or percentage of specimens. CBT HU: Cortical bone trajectory Hounsfield units; TT HU: Traditional trajectory Hounsfield units; BMD: Bone mineral density; DEXA: Dual-energy X-ray absorptiometry; QCT: Quantitative computed tomography.

Baseline characteristics were summarized using descriptive statistics. Paired *t*-tests were used to compare paired variables between the HU values of CBT and TT. The one-way test was used to compare the measured HU values among different vertebral segments. Univariable and multivariable linear regression and partial correlation analyses were used to examine the associations among segments; BMD of vertebrae (independent variables); and CBT HU values, TT HU values, and the ratio of CBT HU and TT HU (CBT HU/TT HU) (dependent variables). The associations between segments and CBT HU values, TT HU values, and CBT HU/TT HU and among BMD and CBT HU values, TT HU values, and CBT HU/TT HU were adjusted for age and gender. A *p*-value < 0.05 (two-tailed) was considered as statistically significant. All statistical analyses were performed using SPSS version 19.0 (IBM Corporation, Armonk, NY, USA).

Results

Detailed information about the specimens' demographics is shown in **Table 1**. The average age of the 40 donors (19 males and 21 females) was 68.7 ± 9.4 years (range: 49-86 years). The mean HU values of CBT and TT were 286.74 ± 120.80 and 165.61 ± 92.38, respectively. No significant difference was observed between the HU values of the CBT and TT of the left and right pedicles at the ROI, whereas a significant difference was found between the HU values of CBT and TT (P = 0.00, t = 24.69). The CBT HU/TT HU was 2.00 ± 0.90.

The average lateral BMD of 240 vertebrae determined using DEXA was 0.540 ± 0.193 g/cm^2 (≤ 0.8 g/cm^2, n = 219, 0.497 ± 0.129 g/cm^2; > 0.8 g/cm^2, n = 21, 0.990 ± 0.177 g/cm^2), whereas the anteroposterior BMD was 0.651 ± 0.180 g/cm^2 (≤ 0.8 g/cm^2, n = 197, 0.587 ± 0.104 g/cm^2; > 0.8 g/cm^2, n = 43,

0.947 ± 0.160 g/cm^2). Furthermore, the average cortical BMD of 240 vertebrae determined using QCT was 245.63 ± 80.09 mg/cm^3, whereas the average cancellous BMD of 240 vertebrae determined using QCT was 88.24 ± 61.78 mg/cm^3 (< 80 mg/cm^3, *n* = 128, 51.41 ± 18.73 mg/cm^3; 80-120 mg/cm^3, *n* = 60, 93.72 ± 10.41 mg/cm^3; > 120 mg/cm^3, *n* = 52, 172.59 ± 78.70 mg/cm^3) (**Table 1**).

The results of univariable and multivariable linear regression and partial correlation analyses showed that the lateral and anteroposterior BMD determined using DEXA were significantly and positively associated with the HU values of CBT and TT (**Tables 2** and **3**; **Figures 2** and **3**). The results of univariable and multivariable analyses revealed that CBT HU values were more significantly and positively associated with the cortical BMD determined using QCT than the TT HU values but less significantly and positively associated with the cancellous BMD determined using QCT (**Tables 2** and **3**; **Figure 4**). The CBT HU/TT HU was remarkably and negatively associated with the lateral BMD determined using DEXA in multivariable analyses and the cancellous BMD determined using QCT in univariable and multivariable analyses; however, it was not significantly associated with the anteroposterior BMD determined using DEXA and the cortical BMD determined using QCT in univariable and multivariable analyses (**Table 4**; **Figures 2**-**4**).

From T9 to L5, the TT HU values decreased significantly, and the CBT HU/TT HU increased significantly, but the CBT HU values did not change significantly in univariable and multivariable linear regression and partial correlation analyses (**Tables 2**-**4**; **Figure 5**). The TT HU values decreased from 230.37 ± 115.87 in T9 to 139.75 ± 67.39 in L5 (*P* = 0.008, *F* = 2.66), and the CBT HU/TT HU increased from 1.67 ± 0.48 in T9 to 2.53 ± 1.30 in L5 (*P* = 0.000, *F* = 5.29) (**Table 5**).

Discussion

The CBT is designed as an alternative of TT to decrease the risk of injury to the innervation of facet joints and multifidus muscle and increase screw-bone interface strength, especially in patients with low BMD [18]. Previous biomechanical studies have demonstrated that CBT has equivalent or better pullout and toggle characteristics compared with TT [7-9], which is possibly due to the difference in the bone density of trajectory. However, Santoni BG [8] found that the pullout strengths of CBT and TT are correlated with BMD measured through QCT scans but not with BMD measured through DEXA scans. This observation may be due to small spread in their BMD data (0.786 ± 0.060 g/cm^2) as approximately 75% of the vertebral bodies biomechanically tested were classified as osteoporotic. Therefore, the BMD of 240 vertebrae was measured using DEXA and QCT, and the spread in our BMD data of DEXA was sufficient (0.540 ± 0.193 g/cm^2). BMD has historically been assessed using DEXA and QCT, but HU measurements from CT images are recently recommended by many studies to assess BMD and estimate bone strength [13, 14, 16]. DEXA can only measure the BMD of vertebrae, which cannot represent the trajectory. During QCT examination, the bone density is the cancellous bone separated from the cortical bone in vertebrae [25, 26]. Moreover, lumbar CT is a routine preoperative examination for patients who need surgery for lumbar degenerative diseases. HU values can make the best use of CT images at no extra cost, and the screw trajectory can be chosen to measure the HU values in the trajectory. Thus, the HU values of the ROI of each trajectory has been measured in the current study. In some radiological studies, the HU values of the CBT are significantly greater than those of the TT, but the BMD of each vertebra cannot be obtained; thus, the correlation between the BMD of vertebrae and the HU values of CBT and TT cannot be examined [17-19]. Therefore, whether the HU values of the trajectory can be applied to assess the BMD of the vertebra and estimate bone strength and screw stability is still uncertain. To the best of our knowledge, this is the first study to use radiological methods in assessing the correlation of the BMD of 240 thoracic and lumbar vertebrae of 40 human spines with the HU values of CBT and TT.

The results showed that the HU values of CBT are almost twice higher than those of TT, and the HU values of both trajectories are significantly and positively correlated with the BMD determined using DEXA and QCT. Previous studies have demonstrated that the HU values of CBT are higher than those of TT [17-19], and other studies have correlated BMD to pullout

Table 2. Associations between BMD, segments and CBT HU values

	Correlation analyses				Linear regression analyses					
	Univariable *r* value	*p* value	Multivariable* *r* value	*p* value	Univariable β	*t* value	*p* value	Multivariable* β	*t* value	*p* value
Segments	0.01	0.94	0.01	0.93	0.01	0.08	0.94	0.01	0.09	0.93
BMD (DEXA, lateral position)	0.56	< 0.001	0.56	< 0.001	0.56	10.30	< 0.001	0.58	10.30	< 0.001
BMD (DEXA, anteroposterior position)	0.54	< 0.001	0.55	< 0.001	0.54	9.87	< 0.001	0.57	10.21	< 0.001
BMD (QCT, cortical bone)	0.51	< 0.001	0.49	< 0.001	0.51	9.21	< 0.001	0.50	8.65	< 0.001
BMD (QCT, cancellous bone)	0.63	< 0.001	0.62	< 0.001	0.63	12.56	< 0.001	0.64	12.01	< 0.001

Dependent variable: CBT HU values; Independent variable: BMD, segments. *Adjusted for age, gender between segments and CBT HU values, adjusted for age, gender and segments between BMD and CBT HU values. β: standard partial regression coefficient. CBT HU: Cortical bone trajectory Hounsfield units; BMD: Bone mineral density; DEXA: Dual-energy X-ray absorptiometry; QCT: Quantitative computed tomography.

Table 3. Associations between BMD, segments and TT HU values

	Correlation analyses				Linear regression analyses					
	Univariable *r* value	*p* value	Multivariable* *r* value	*p* value	Univariable β	*t* value	*p* value	Multivariable* β	*t* value	*p* value
Segments	-0.22	0.001	-0.22	0.001	-0.22	-3.42	0.001	-0.22	-3.52	0.001
BMD (DEXA, lateral position)	0.41	< 0.001	0.48	< 0.001	0.41	6.99	< 0.001	0.48	8.34	< 0.001
BMD (DEXA, anteroposterior position)	0.36	< 0.001	0.44	< 0.001	0.36	5.86	< 0.001	0.43	7.43	< 0.001
BMD (QCT, cortical bone)	0.42	< 0.001	0.42	< 0.001	0.42	7.16	< 0.001	0.41	7.09	< 0.001
BMD (QCT, cancellous bone)	0.74	< 0.001	0.71	< 0.001	0.74	16.77	< 0.001	0.71	15.54	< 0.001

Dependent variable: TT HU values; Independent variable: BMD, segments. *Adjusted for age, gender between segments and TT HU values, adjusted for age, gender and segments between BMD and TT HU values. β: standard partial regression coefficient. TT HU: Traditional trajectory Hounsfield units; BMD: Bone mineral density; DEXA: Dual-energy X-ray absorptiometry; QCT: Quantitative computed tomography.

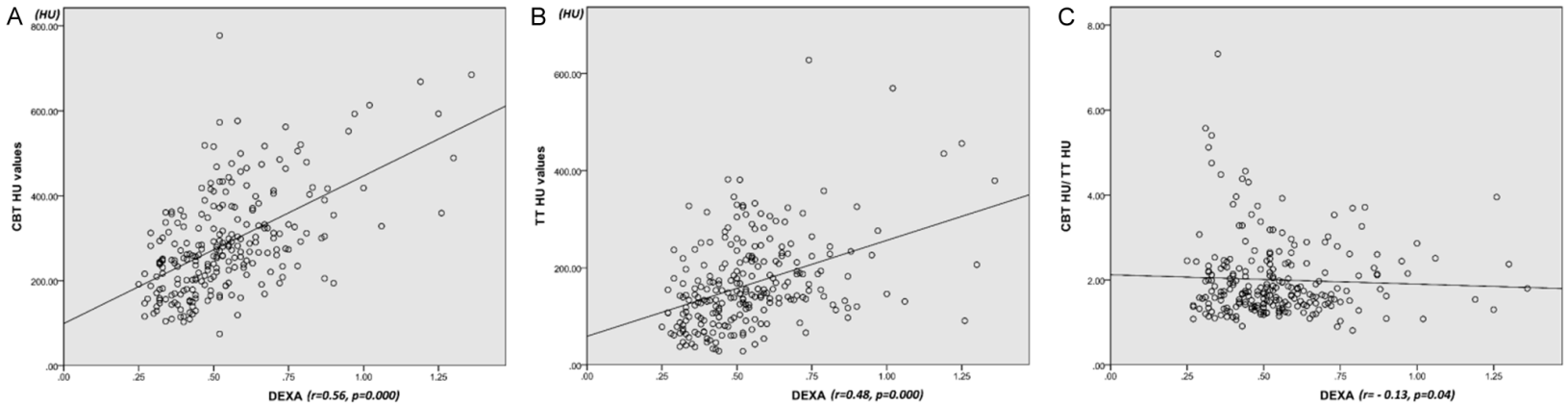

Figure 2. A. The lateral BMD determined using DEXA was significantly and positively associated with CBT HU values. B. The lateral BMD determined using DEXA was significantly and positively associated with TT HU values. C. The latera BMD determined using DEXA was significantly and negatively associated with CBT HU/TT HU. BMD, bone mineral density; HU, Hounsfield unit.

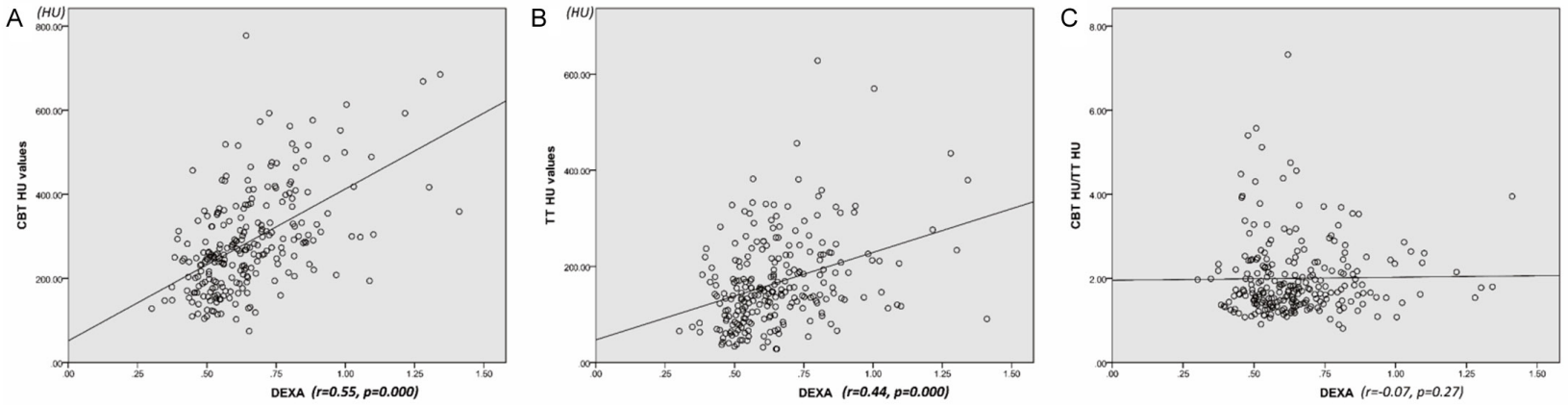

Figure 3. A. The anteroposterior BMD determined using DEXA was significantly and positively associated with CBT HU values. B. The anteroposterior BMD determined using DEXA was significantly and positively associated with TT HU values. C. The anteroposterior BMD determined using DEXA was insignificantly associated with CBT HU/TT HU. BMD, bone mineral density; HU, Hounsfield unit.

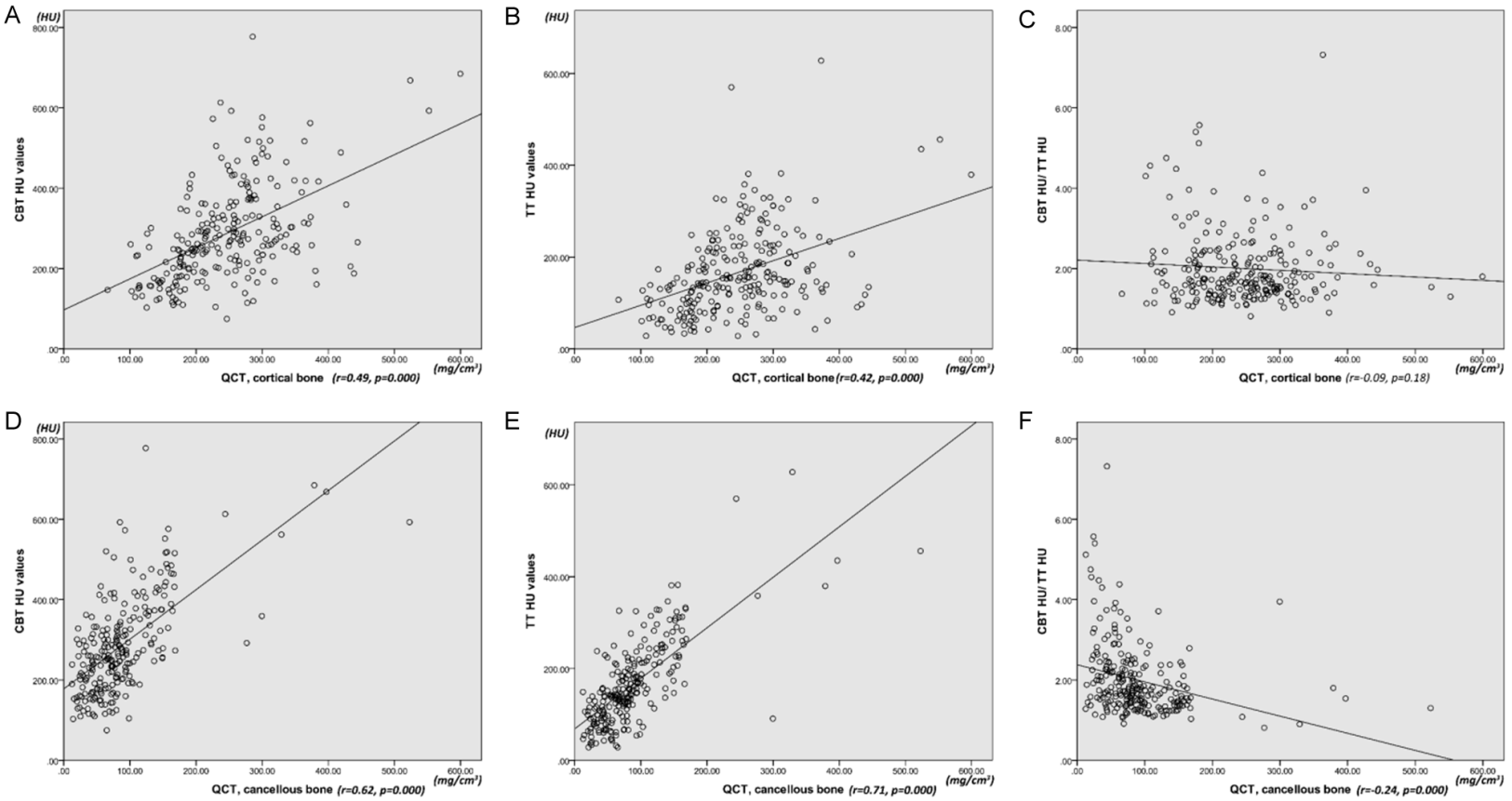

Figure 4. A, B. The CBT HU was more significantly and positively associated with the cortical BMD determined using QCT than the TT HU values. C. The CBT HU/TT HU was not significantly associated with the cortical BMD determined through QCT. D, E. The CBT HU was less significantly and positively associated with the cancellous BMD determined using QCT. F. The CBT HU/TT HU was significantly and negatively associated with the cancellous BMD determined using QCT.

Table 4. Associations between BMD, segments and CBT HU/TT HU

	Correlation analyses				Linear regression analyses					
	Univariable *r* value	*p* value	Multivariable* *r* value	*p* value	Univariable β	*t* value	*p* value	Multivariable* β	*t* value	*p* value
Segments	0.34	< 0.001	0.35	< 0.001	0.34	5.62	< 0.001	0.34	5.68	< 0.001
BMD (DEXA, lateral position)	-0.05	0.47	-0.13	0.04	-0.05	-0.73	0.47	-0.12	-1.93	0.04
BMD (DEXA, anteroposterior position)	0.01	0.83	-0.07	0.27	0.01	0.22	0.83	-0.07	-1.11	0.27
BMD (QCT, cortical bone)	-0.07	0.25	-0.09	0.18	-0.07	-1.15	0.25	-0.08	-1.35	0.18
BMD (QCT, cancellous bone)	-0.29	< 0.001	-0.24	< 0.001	-0.29	-4.70	< 0.001	-0.24	-3.84	< 0.001

Dependent variable: CBT HU/TT HU; Independent variable: BMD, segments. *Adjusted for age, gender between segments and CBT HU/TT HU, adjusted for age, gender and segments between BMD and CBT HU/TT HU. β: standard partial regression coefficient. CBT HU: Cortical bone trajectory Hounsfield units; TT HU: Traditional trajectory Hounsfield units; BMD: Bone mineral density; DEXA: Dual-energy X-ray absorptiometry; QCT: Quantitative computed tomography.

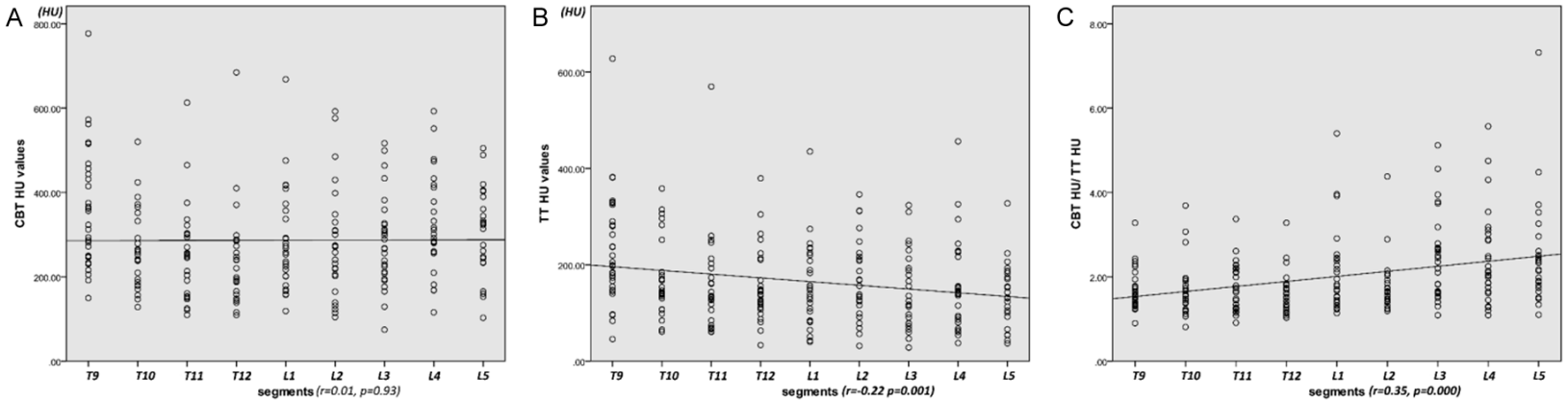

Figure 5. A. The CBT HU values did not change significantly from T9 to L5. B. The TT HU values decreased significantly from T9 to L5. C. The ratio of CBT HU/TT HU increased significantly from T9 to L5.

Table 5. HU values at the trajectory of CBT and TT in different segments

Segment	Number	CBT HU values*	TT HU values*	CBT HU/TT HU*
T9	30	353.60 (140.44)	230.37 (115.87)	1.67 (0.48)
T10	25	265.46 (96.73)	173.23 (81.81)	1.70 (0.65)
T11	27	250.83 (111.80)	160.32 (103.38)	1.75 (0.56)
T12	26	237.85 (118.21)	156.96 (78.05)	1.62 (0.49)
L1	27	282.63 (120.52)	157.04 (86.64)	2.10 (0.99)
L2	26	278.90 (131.89)	168.10 (82.67)	1.78 (0.65)
L3	28	279.58 (108.50)	137.20 (81.89)	2.46 (1.01)
L4	27	320.57 (116.65)	158.83 (95.29)	2.43 (1.10)
L5	24	302.12 (104.25)	139.75 (67.39)	2.53 (1.30)

*Data were presented as mean (SD). CBT HU: Cortical bone trajectory Hounsfield units; TT HU: Traditional trajectory Hounsfield units.

strength and insertional torque [8, 27, 28]. Therefore, the positive correlation of the BMD and HU values of both trajectories indicates that the HU values of both trajectories are positively correlated with pullout strength and insertional torque. In addition, a retrospective cohort study found that the regional HU values of the CBT screw trajectory are strongly correlated with insertional torque, which is based on the shearing force and friction of the bone screw interface during screw insertion [29]. Furthermore, the CBT HU values were more significantly and positively associated with the cortical BMD determined using QCT than the TT HU values and less significantly and positively associated with the cancellous BMD determined using QCT. This difference may be because the CBT engages more cortical bone in the pedicle, whereas approximately 80% of the TT is cancellous bone [7]. The present study also demonstrated that the CBT HU/TT HU was remarkably and negatively associated with the lateral BMD determined using DEXA and the cancellous BMD determined using QCT, respectively. However, it was not significantly associated with anteroposterior BMD determined using DEXA and the cortical BMD determined using QCT. The reason may be explained by the fact that the anteroposterior BMD measured by DEXA includes the spinous process, lamina, articular process, vertebral body, etc. The anteroposterior BMD is the BMD mixed with cancellous bone and cortical bone, whereas the lateral BMD measured by DEXA is only the vertebral body, which can represent the cancellous bone and more accurately reflect the actual bone density of the vertebral body. Therefore, the lateral BMD measured by DEXA and cancellous bone BMD measured by QCT are sensitive and accurate in reflecting BMD. This finding is important because the cancellous bone is more affected by osteoporosis than the cortical bone [7], and patients with osteoporosis have an increased risk of hardware migration, loosening, and failure after spine fusion procedures [19]. Therefore, the interface of high bone density provided by the CBT achieves adequate fixation that is less affected by the cancellous bone quality, indicating that CBT may be a better method of fixation than TT in patients with osteoporosis for spine surgeons.

Previous studies revealed a significant difference in the CBT and TT HU values between male and female patients of different ages [17, 18]. Therefore, the correlation among the segments and CBT HU values, TT HU values, and CBT HU/TT HU was assessed by eliminating the effects of age and gender. Through univariable and multivariable linear regression and partial correlation analyses, the current study demonstrated that the segments are significantly negatively associated with TT HU values, significantly positively associated with CBT HU/TT HU, and have no correlation with the CBT HU values by adjusting for age and gender between the segments and the CBT HU values, TT HU values, and CBT HU/TT HU. The data showed that CBT HU/TT HU increased from 1.67 ± 0.48 in T9 to 2.53 ± 1.30 in L5. This result indicates that in the application of CBT screws, the lumbar spine has advantages over the thoracic spine, and the superiority of the lower lumbar spine is more obvious. This finding may be related to the greater stress on the lower lumbar segment, which is consistent with the anatomy of the spine. The pedicle diameters of T9-L2 are often smaller than those of L3-L5, and some of the pedicle diameters of T9-L2 may be smaller than the ROI, which indicates that placing CBT screws in T9-L2 is difficult [18, 20]. Thus, surgeons should advance the CBT screw slowly using a C arm or CT image-guided navigation to confirm its accurate placement. At

present, CBT screws are mainly used in the lumbar spine, especially the lower lumbar area [30, 31]. Some scholars believe that the safest segments of placing CBT screws are L3-L5 [32]. Therefore, from the point of view of the trajectory density and pedicle size, CBT has obvious advantages in the lower lumbar spine.

This study has several limitations. First, cadaveric spines, which have slightly different properties compared with the bones of patients, were used. Second, the ROI was used to represent the ideal trajectory of CBT and TT. However, the actual surgical technique and trajectory may be slightly different depending on the surgeon.

Conclusions

To the best of our knowledge, this is the first study to use radiological methods in assessing the correlation between the BMD of 240 thoracic and lumbar vertebrae of 40 human spines and the HU values of CBT and TT. The HU values of CBT and TT significantly decrease with decreasing BMD, and the CBT HU values significantly decrease less than the TT HU values, especially in low-BMD vertebrae and cauda lumbar segments. Thus, the HU values of the trajectory can be useful in medical and surgical management for pedicle screw stability prediction, especially in medical institutions with no QCT, and may avoid DEXA evaluation for some patients.

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Disclosure of conflict of interest

None.

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