Review Article
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Degenerativa

HOUNSFIELD UNITS USE IN SPINAL SURGERY PLANNING: SYSTEMATIC REVIEW AND META-ANALYSIS

USO DAS UNIDADES HOUNSFIELD NO PLANEJAMENTO DA CIRURGIA ESPINHAL: REVISÃO SISTEMÁTICA E META-ANÁLISE

USO DE LAS UNIDADES HOUNSFIELD EN LA PLANIFICACIÓN DE LA CIRUGÍA ESPINAL: REVISIÓN SISTEMÁTICA Y METANÁLISIS

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ABSTRACT

Bone mineral density is a crucial factor in the success or failure of osteosynthesis in spine surgery; it shows the onset of osteoporosis and related complications. Its evaluation is verified by dual-energy X-ray absorptiometry (DEXA) and Hounsfield Unit (HU) measurement by CT scan. Objective: Determine the use of HU in surgical planning; compare utility in diagnosing osteoporosis by DEXA; and evaluate sensitivity in predicting complications. Method: A systemic literature review was conducted on PubMed, in line with PRISMA methodology. Including those who justified the use of pre-surgical planning, compared HU/DEXA, and assessed complications. For the statistical analysis, the χ^2 was used. Results: 57 articles were identified by selecting nine that met the inclusion criteria. In patients undergoing spinal surgery for fixation and fusion for degenerative pathology, HU measurement showed a prevalence of osteoporosis of 58.5% (sensitivity 93.26%; specificity 90.22%), osteoporosis-associated complications of 24.5%, proper diagnosis of 71.98%, and screw release rate of 82.31%. Conclusions: UH measurement for the diagnosis of osteoporosis turns out to be more sensitive, specific, and predictive compared to DEXA, especially in elderly patients; it represents a useful tool in planning spinal surgery, minimizing the risk of complications such as screw release, fractures, pseudoarthrosis, subsidence of intersomatic devices, and kyphosis of the proximal junction. **Level of evidence II; Study Design: Systematic Review and meta-analysis.**

Keywords: Absorptiometry, Photon; Bone Density; Osteoporosis; Bone Screws; Tomography; Kyphosis.

RESUMO

A densidade mineral óssea é um fator crucial no sucesso ou falha da osteossíntese na cirurgia da coluna vertebral; isso mostra o aparecimento da osteoporose e complicações relacionadas a ela. Sua avaliação é verificada por absorptiometria de raios-X de dupla energia (DEXA) e medição da Unidade Hounsfield (HU) por tomografia. Objetivo: Determinar o uso do HU no planejamento cirúrgico; comparar utilidade no diagnóstico de osteoporose pelo DEXA; e avaliar a sensibilidade na previsão de complicações. Método: Foi realizada uma revisão de literatura sistêmica no PubMed, em consonância com a metodologia PRISMA. Incluindo aqueles que justificaram o uso do planejamento pré-cirúrgico, comparou o HU/DEXA e avaliaram complicações. Para a análise estatística, o χ^2 foi usado. Resultados: Inicialmente foram identificados 57 artigos por meio da seleção de nove que atenderam aos critérios de inclusão. Em pacientes submetidos à cirurgia espinhal para fixação e fusão por patologia degenerativa, a medição do HU apresentou prevalência de osteoporose de 58,5% (sensibilidade 93,26%; especificidade 90,22%), complicações associadas à osteoporose de 24,5%, diagnóstico adequado de 71,98% e taxa de liberação de parafusos de 82,31%. Conclusões: A medição da UH para o diagnóstico da osteoporose acaba sendo mais sensível, específica e preditiva em relação ao DEXA, principalmente em pacientes idosos; representa uma ferramenta útil no planejamento da cirurgia espinhal, minimizando o risco de complicações como liberação de parafusos, fraturas, pseudoartrose, subsidência de dispositivos intersomáticos e cifose da junção proximal. ***Nível de evidência II; Revisão Sistemática e meta-análise.***

Descritores: *Absorciometria de Fóton; Densidade Óssea; Osteoporose; Parafusos ósseos; Tomografia; Cifose.*

RESUMEN

La densidad mineral ósea es un factor crucial en el éxito o fracaso de la osteosíntesis en la cirugía espinal; esto muestra la aparición de osteoporosis y las complicaciones relacionadas con ella. Su evaluación se verifica mediante absorciometría de rayos X de energía dual (DEXA) y medición unitaria de Hounsfield (HU) por tomografía. Objetivo: Determinar el uso de HU en la planificación quirúrgica; comparar la utilidad en el diagnóstico de osteoporosis por DEXA; y evaluar la sensibilidad en la predicción de complicaciones. Método: Se realizó una revisión sistémica de la literatura en PubMed, en línea con la metodología PRISMA. Incluyendo aquellos que justificaron el uso de la planificación prequirúrgica, compararon HU/DEXA y evaluaron las complicaciones. Para el análisis estadístico se utilizó χ^2. Resultados:

Study conducted by the HIGA San Martín La Plata. 1 y 70 La Plata - Buenos Aires (Argentina).
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Inicialmente se identificaron 57 artículos seleccionando 9 que cumplían con los criterios de inclusión. En pacientes sometidos a cirugía espinal por fijación y fusión por patología degenerativa, la medición de HU mostró una prevalencia de osteoporosis del 58,5% (sensibilidad 93,26%; especificidad 90,22%), complicaciones asociadas a osteoporosis del 24,5%, diagnóstico adecuado del 71,98% y tasa de liberación de tornillo del 82,31%. Conclusiones: La medición de la UH para el diagnóstico de osteoporosis resulta ser más sensible, específica y predictiva en comparación con el DEXA, principalmente en pacientes de edad avanzada; representa una herramienta útil en la planificación de la cirugía espinal, minimizando el riesgo de complicaciones como la liberación del tornillo, fracturas, pseudoartrosis, hundimiento de dispositivos intersomáticos y cifosis de la unión proximal. ***Nivel de evidencia II; Revisión sistemática y meta-análisis.***

Descriptores: *Absorciometría de Fotón; Densidad Ósea; Osteoporosis; Tornillos Óseos; Tomografía; Cifosis.*

INTRODUCTION

With the aging of the population, osteoporosis gradually becomes a global health problem affecting 200 million people worldwide,[1] it has been estimated that there will be more than 400 million elderly and 200 million osteoporotic patients in China by the year 2050.[2] It is evaluated that, in the U.S.A, 15% of the population are at risk of disability or death because of osteoporotic[3] complications. Postmenopausal white women are at high risk, with 30% suffering from systemic osteoporosis and 16% had osteoporosis at the lumbar level.[4]

Approximately 25% of women over the age of 70 will experience at least one vertebral body compression fracture, with this number increasing to over 50% in women over the age of 80.[5] Given the growth rate of the elderly population, an increase in the incidence can be expected, and this demographic group will constitute a growing group in need for care. Osteoporosis predisposes patients to deformity and stenosis, and fracture and surgical correction in these patients remain difficult.[6]

Despite this, evidence remains scant on what approaches or strategies should be employed in this patient population. These strategies include pharmacologic treatment, using multiple fixation points in the osteoporotic spine, pedicle screw cement augmentation, and novel pedicle screw designs intended to increase fixation.[7] Lumbar surgeries are performed three times more frequently in patients ≥ 60 years than in younger patients.[8] The rate of osteoporosis in older patients is reported to be higher than that in the general population, with a rate of 50% in elderly patients.[9]

Pedicle screw fixation is a common procedure used in the surgical treatment of lumbar degenerative diseases. In contrast, the osteoporotic lumbar spine has created great challenges in maintaining the stability of lumbar fixation. Pedicle screw loosening is one of the main reasons for secondary surgical interventions after lumbar surgery, and osteoporosis, or low bone mineral density (BMD), is the most frequent risk factor for screw loosening.

Although the reported incidence of screw loosening varies among the different published studies, in patients with osteoporosis, the risk of screw loosening is twice that of patients without osteoporosis. Between 6.3% and 15.6% of patients with screw loosening require revision surgery.[8]

One of the main challenges of osteoporosis and osteopenia management on spine surgical outcomes is the lack of a preoperative "gold standard" prognostic measure to determine the risk of osteoporosis-related complications after spinal fusion surgery.[10]

Various radiographic measurements such as Hounsfield units (HU), FRAX score, and T-scores (T-score) on dual-energy X-ray absorptiometry (DXA) have been studied in the setting of osteoporosis/osteopenia and spine surgery.[11]

While DXA scores have been considered the gold standard for osteoporosis assessment, the International Society for Clinical Densitometry recommends that, in patients with degenerative spine disease, DXA of the lumbar spine should not be used, as these focal structural changes may falsely elevate the reported BMD.[3]

CT of the lumbar spine has shown promise in predicting bone density,[12,13] and various complications in patients with a degenerative lumbar spine.[14]

This study aims to determine the use of HU in surgical planning; compare its usefulness in osteoporosis diagnosis by DEXA; and assess the sensitivity in predicting complications.

MATERIAL AND METHOD

This study was conducted following "Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement" (PRISMA).[15]

Data sources and search

A literature search was performed in the databases PubMed, Scielo, and Lilacs, from May 5 to May 20, 2021, with the search terms related to Hounsfield Units, lumbar spine, and surgery, without language restrictions, results by year, text availability, article attribute, article type, publication date, in humans.

Eligibility criteria

Articles that used the measurement of Hounsfield Units in spinal surgery planning were selected, provided a therapeutic recommendation or course of action based on the measurements, and compared Hounsfield Units and DXA.

Exclusion criteria

Articles with incomplete data, repeated data, pharmacological evaluations, abstracts, case reports and letters, laboratory or phantom studies, complications other than those related to osteopenia and osteoporosis, unpublished studies, conferences, and theses, from October 1993 to February 2021 were excluded.

RESULTS

The initial search showed the presence of 57 studies carried out in PubMed. After the first review of relevance, 48 (forty-eight) used the measurement of Hounsfield Units in the planning of spinal surgery, 35 (thirty-five) articles made a recommendation or therapeutic conduct based on the measurements of Hounsfield Units, 16 (sixteen) articles compared Hounsfield Units and DXA, 12 (twelve) articles met all the inclusion criteria, 2 (two) of which presented exclusion criteria of pharmacological intervention type (28) (29), and 1 (one) was duplicated(30), finally nine articles were selected. Nine (9) studies did not meet the inclusion criteria. (Figure 1)

Data Analysis

After selecting the nine articles that meet all the eligibility criteria (Table 1), three studies are carried out according to the object of study of each author, firstly comparing the results between Hounsfield units and bone densitometry in the diagnosis of osteoporosis for a total of 3 articles; A second group where the probable complications related to osteoporosis diagnosed by tomographic Hounsfield Units are determined for a total of 6 articles, within the same, the probability of loosening of the screws in the instrumentation of the lumbar spine in patients with osteoporosis diagnosed by tomographic Hounsfield Units is evaluated; for determination of prevalence, sensitivity, specificity, positive predictive value, negative predictive value, positive probability ratio, and negative probability ratio.

In relation to the first grouping (Table 2), a prevalence in the diagnosis of osteoporosis by Hounsfield Units of 58.51% (95% CI: 55.18% to 61.77%), sensitivity of 93.26% (95% CI: 90.66% to 95.19%), specificity of 90.22% (95% CI: 86.60% to 92.97%), positive predictive value 93.08% (95% CI: 90.46% to 95.04%), negative

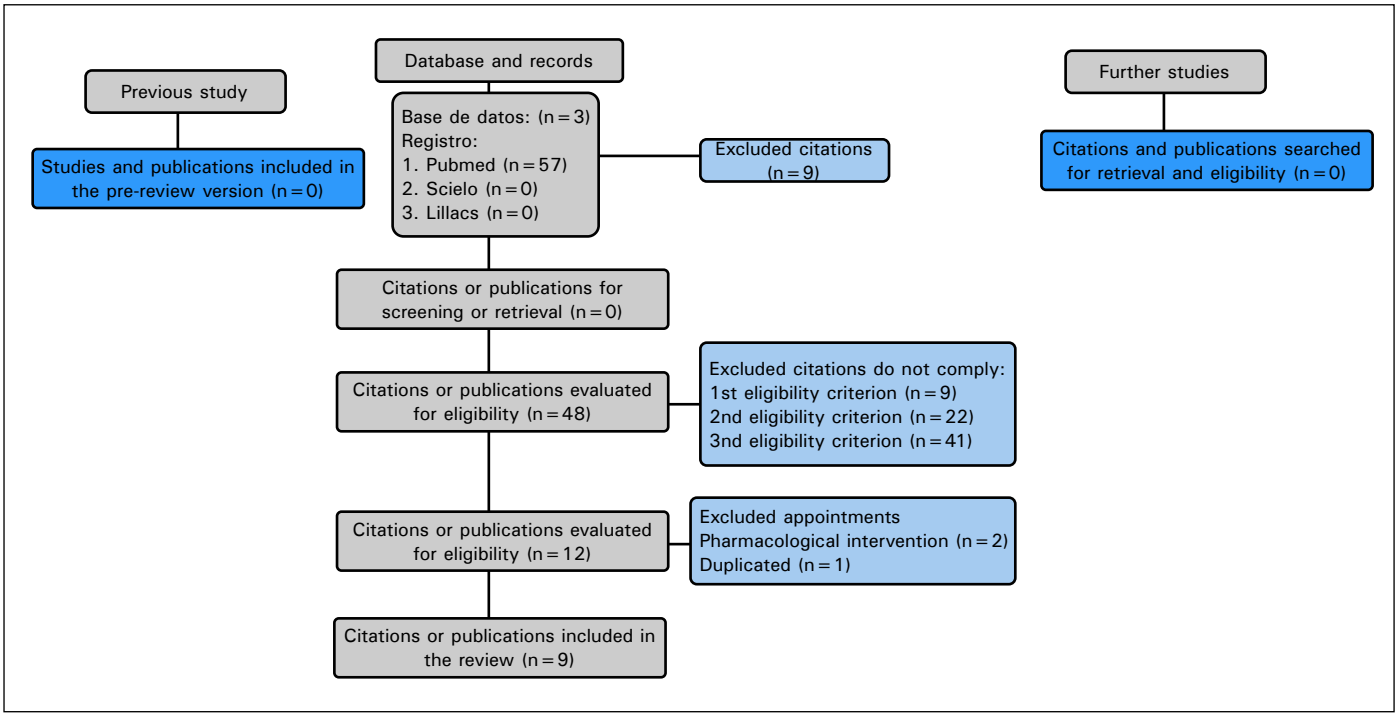

Figure 1. Flow diagram according to PRISMA 2020.

Table 1. Summary of the nine articles included that met the inclusion criteria.

Author (Year)	Patients (n)	Approach	Conclusions	Type
Kim[21] (2019)	503	Comparative study of HU vs. DEXA.	Significant correlation between HU and BMD. HU is considered a predictive factor for osteoporosis.	R
St Jeor17 (2020)[]	140	Comparative study under evaluation of BMD, HU, and DEXA to determine complications associated with osteoporosis	HU is a predictive factor of complications of osteoporosis.	R
Ullrich [18] (2018)	81	Evaluate the HUs for possible determination of the risk of subsidence of the boxes.	HU measurement is recommended in pre-surgical planning.	R
St Jeor [19] (2020)	244	Compare DEXA and HU, a study in patients with degenerative spinal pathology.	Extension of the concept of spinal osteoporosis for patients with poor bone quality.	R
Matsukawa [20] (2018)	92	Demonstrate the usefulness of HU in the screw path to predict the primary and long-term fixing force of the pedicle screws.	The regional HU values of the screw path could strongly predict both primary and long-term live screw fixation.	R
Berger-Groch[21] (2018)	531	Collect information on BMD by HT in CT of patients with sacral fractures.	HU is a simple procedure to further assess bone quality in patients with pelvic ring fractures.	R
Bredow [22] (2016)	365	UH was evaluated in 365 patients to determine the BMD of each vertebral body.	The determination of bone density by pre-operative computed tomography can predict the risk of loosening the screws and inform the decision to use magnification cement to reduce the incidence of loosening the screws.	R
Xu [23] (2020)	143	UH, values of the vertebral body and pedicle as predictors of post-surgical pedicular screw loosening.	The HUs of the vertebral body alone are not enough to accurately assess the risk of loosening the pedicle screw.	R
Zou D [8] (2020)	503	The loosening rate of the pedicular screw at 12 months of follow-up was 30.0%.	The HU value measured on CT was an independent predictor of pedicular screw loosening; low HU values correlate significantly with an increased risk of screw loosening.	R

UH = Hounsfied units; DXA = Bone Densitometry, BMD = Bone Mineral Density; CT = Tomography; R = Retrospective.

predictive value 90.46% (95% CI: 86.87% to 93.18%), positive likelihood ratio 9.53 (95% CI: 6.98 to 13.01), p = 0.07 (95% CI: 0.05 to 0.10).

Regarding the second grouping, a first comparative table is determined with respect to the complications associated with the diagnosis of Osteoporosis performed by Hounsfield Units by tomography (Table 3), a prevalence of osteoporosis of 24.55% (95% CI: 22.85% to 26.34%) is defined, adequate diagnosis of 71.98% (95% CI: 70.13% to 73.77%), sensitivity 43.37% (95% CI: 39.33% to 47.49%), specificity 94.65% (95% CI: 93.38% to 95.69%), positive predictive value 75.44% (95% CI: 70.43% to 79.87%), negative predictive value 71.41% (95% CI: 69.40% to 73.35%), positive likelihood ratio 8.11 (95% CI: 6.42 to 10.24), p = 0.60 (95% CI: 0.57 to 0.63).

The most common complications include additional fractures (pedicle/compression), pseudarthrosis, and instrumentation failure secondary to poor fixation in osteoporotic bone or progression of the spinal disease due to altered biomechanics (24).

A second comparative table associates the risk of screw loosening in spinal surgery in relation to the diagnosis of Osteoporosis performed by Hounsfield Units (Table 4), with a loosening prevalence of 82.31% (95% CI: 15.72% to 19.85%), adequate diagnosis 82.60% (95% CI: 93.27% to 95.75%), sensitivity 6.16% (95% CI: 95.52% to

Table 2. Comparative Study between Hounsfield Tomographic Units and Bone Densitometry in the Diagnosis of Osteoporosis.

n (patients with osteoporosis)		DEXA study		Total
		N (patients without osteoporosis)		
Hounsfield Units	n (patients with osteoporosis)	484	36	520
	n (patients without osteoporosis)	35	332	367
Total		519	368	887

The cut-off value for osteoporosis diagnosis by UH: less than 110 HU. A cut-off value for the diagnosis of osteoporosis by DEXA: -2.5 (T-score).

Table 3. Hounsfield Units performed post-surgical complications associated with the diagnosis of osteoporosis.

Patients with osteoporosis		Diagnosis by Tomographic HU		Total
		Patients without osteoporosis		
Complications	Patients with osteoporosis	255	83	338
	Patients without osteoporosis	588	1469	2057
Total		843	1552	2395

A cut-off value for the determination of BMD for Hounsfield Units: ≤110 HU osteoporosis, 110 -180 UH osteopenia, ≥180 normal.

Table 4. Post- Surgery pedicle screw loosening associated with an osteoporosis diagnosis made by Houndsfield Units.

Patients with osteoporosis		Diagnosis by Tomographic HU		Total
		Patients without osteoporosis		
Pedicle screw loosening	Patients with osteoporosis	237	69	306
	Patients without osteoporosis	4	1052	1056
Total		241	1121	1362

A Cut-Off value for determining BMD by Houndsfield Units: ≤110 HU osteoporosis, 110-180 HU osteopenia, ≥180 normal.

99.47%), specificity 77.53% (95% CI: 92.23% to 95.15%), positive predictive value 77. 45% (95% CI: 72.27% to 81.93%), negative predictive value 99.42% (95% CI: 98.96% to 99.88%), positive likelihood ratio 15.98 (95% CI: 12.70 to 20.09), p = 0.02 (95% CI: 0.01 to 0.05).

DISCUSSION

The World Health Organization (WHO) classifies bone health in adults > 50 using the (BMD) bone mineral density test in the lumbar spine and hip, compared with a reference standard taken from young white women. Osteoporosis is defined as a T-score of -2.5, osteopenia is defined as T-score between -1.0 and -2.4, and the normal bone density as T-score > -1.0 under this premise.[1]

The lumbar surgeries are frequently performed three times more in patients ≥ 60 years old than in younger ones. It is informed that the rate of osteoporosis in older patients is higher than in the general population, with a rate of 50% in patients of advanced age. The pedicle screw fixation is a common procedure in the surgical treatment of degenerative lumbar illnesses. In contrast, the osteoporotic lumbar spine has created great challenges in maintaining the stability of the lumbar fixation. The most common complications include additional fractures (pedicle/compression), pseudoarthrosis, secondary instrumentations failure due to a bad fixation in an osteoporotic bone, or a spinal illness progression as a result of altered biomechanics.[16]

Despite all that, the evidence continues to be limited about what approaches or strategies should be used for this patient population. Some examples of these strategies include pharmacological treatment, using multiple fixation points in the osteoporotic spine, cement augmentation in the pedicle screw, and innovative designs of pedicle screws intended to increase the fixation.[7]

The loosening of the pedicle screw is one of the main reasons for secondary surgical interventions after lumbar surgery, and osteoporosis, or low bone mineral density (BMD), is the most frequent risk factor of the screw loosening.

Although the reported incidence of screw loosening varies among the different studies that have been published, in patients with osteoporosis, the risk of screw loosening is twice as much as those of patients without osteoporosis, and between 6,3% and 15,6% of the patients with screw loosing required revision surgery.[8]

Since in these patients, the values of BMD measured by DEXA can be overrated, since 2011, the tomographic measurement of the UH1,[12,17,18] has been recommended, called like that in honor of the creator of the Computed Axial Tomography.[19] Although it is represented as a grayscale, where the black is the air, the white the cortical bone, and the grey is water; it can also be mathematically represented by the following equation:[20] 1000 (μmatter μwater/μwater - μair).

Kim et al.,[16] refer to the measurement of HU value, with excellent interobserver reliability of 0.961 (p=.000), HU value was significant as a predictor of osteoporosis, the sensitivity and specificity were 94.3% and 87.5%, respectively when the optimal cut-off value was below 146 in HU-based prediction of osteoporosis. The positive and negative predictive values were 97.6% and 74.5%, respectively. According to this author, DXA is the gold standard for assessing BMD. However, DXA may show inaccurate BMD results in patients with severe degeneration, aortic calcification, and obesity. BMD may be overestimated in these cases, and DXA may demonstrate incorrect normal values despite clinical osteoporosis.

St Jeor et al.[17,] on the other hand, take into account ORC (osteoporosis-related complications) such as: revision surgery, compression fracture, proximal junction kyphosis (PJK), pseudarthrosis, accelerated adjacent segment disease, or instrumentation failure (including screw loosening), showed significant differences between patients with and without complications in terms of the various bone density measures. Patients with complications had significantly lower DXA T-scores and lower HU. When they analyzed a multivariable binary regression model, the only factors that were independent predictors of complications were teriparatide treatment (OR 5.20, 95% CI 1.48-18.32, p=0.009) and lower mean HU (OR 0.00 595% CI 0.0001-0.1713, p=0.001). Thus they define that the odds of complications increased by 1.7 times for every decrease in average HU of 25 points, or three times for every 50 points. This author mentions that using 110 HU as the lower normal limit provides a 52-60% sensitivity to distinguish osteoporosis from osteopenia and normal BMD in the lumbar region.

Ulrich et al.,[18] demonstrated that HU had significant effects on planning on cage subsidence and loss of reduction following two-step posterior-anterior spinal stabilization for TTSF (traumatic thoracolumbar spine fractures). They divided the HU into subgroups: group 1: HU ≤110, N = 10 (osteoporosis), group 2: HU> 110 and ≤180, N = 43 (osteopenia), group 3: HU> 180, N = 28 (healthy bone tissue). Group 1 and group 2 had significantly greater reduction loss than group 3. The greater the mismatch between endplates and cage, the greater the subsidence; to minimize risk, they should be as similar as possible. We compared HU with DXA for identifying osteoporosis and found: 160 HU, sensitivity of 90%, and 110 HU, specificity of 90%, for the diagnosis of osteoporosis. Rectangular and larger cages are recommended in patients with HU between 110 and 180 HU, with footprints adapted to the patient's anatomy and additional anterior stabilization with the plate. They recommend augmentation with PMMA in the screws and vertebroplasty of the fractured vertebral body in severe osteoporosis. According to this author, cage subsidence was associated with low HU values as a predictor of failure in single level (L4 / 5) transforaminal lumbar interbody fusion (TLIF). HU measurement would allow detection of reduced bone quality before surgery and optimize planning.

Duan et al.[25] refer to PJK (Proximal Junctional Kyphosis): sagittal Cobb angle between the inferior endplate of the UIV (upper instrumented vertebra) and the superior endplate of the UIV + 2, at least 10° greater than the preoperative measurement, associated with Type 1 lesions: disc and ligament failure; Type 2: bone fracture; Type 3: failure of the implant-bone interface. The prevalence of PJK in long fusions is between 5.8% and 62%. It is associated with low bone mineral density (BMD) as a potential risk factor, usually assessed by dual-energy X-ray absorptiometry (DXA). However, not always accurate due to degeneration and instrumentation. Postoperative pelvic tilt ($p = 0.003$) and pelvic T1 incidence ($p = 0.014$) was significantly higher in patients with KJP than in those without. According to this author, the optimal HU value according to Youden's index was: 104 HU in IVUS (sensitivity 0.840, specificity 0.517), 113 HU in IVUS + 1 (sensitivity 0.720, specificity 0.517) and 110 HU in IVUS + 2 (sensitivity 0.880, specificity 0.448). PJK was associated with lower HU values on CT in IVUS, IVUS + 1, and IVUS + 2.

Choi et al.,[26] define a strong positive correlation between HU and T-score (DXA) in patients with a degenerative disease; +100 HU is similar to a T-score of -2.0, +150 HU is similar to a T-score of -1.0, and +200 HU is similar to T-score of 0.0, with a sensitivity of 88.2% and specificity of 85.7%. They report that the degenerative group had a weak correlation with higher error rates concerning T-score and actual BMD. The use of HU in degenerative patients led to more accurate BMD measurements.

Soldozy et al.,[7] mention that HU can be an effective tool when evaluating patients preoperatively and predicting postoperative outcomes. Minimally invasive and percutaneous methods are similar concerning fusion rates and symptom relief, with the added benefit of reduced operative time, blood loss, and potentially reduced complication rates in minimally invasive approaches. Vertebral augmentation has the potential to reduce screw loosening, although cement leakage is a common occurrence and its clinical significance is unclear. The use of cortical pedicle fixation path screw may be superior to traditional pedicle screw placement.

Matsakawa et al.,[27] in the study with 92 operated patients, 12 patients had signs of loosening, relative to HU (× 1000) with HU of 7.68 and 13.0 for fixed screws ($p < 0.001$) (OR = 0.70; 95% confidence interval = 0.56-0.84; $p = 0.018$) was a significant independent risk factor for the occurrence of pedicle screw loosening. Factors that may contribute to the incidence of screw loosening: (1) age, (2) sex, (3) body mass index (BMI), (4) primary disease, (5) BMD of the femoral neck, (6) BMD of the lumbar vertebrae, (7) HU threshold, (8) spinal level of screw insertion, (9) screw length, (10) screw fit in the pedicle (% fill), and (11) screw depth in the vertebral body.

Bredow et al.,[22] mentioned that the incidence of screw loosening, with clinically significant back pain, was around 20%, and screw loosening is one of the main indications for revision in spine surgery. The study shows an incidence of screw loosening in 12.3% of the operated patients, corresponding to 4.7% of the total number of pedicle screws inserted.

According to the results of our study, the routine measurement of Hounsfield units in surgical planning has shown similar results to the "gold standard" method in the diagnosis of osteoporosis, with a prevalence in the diagnosis of osteoporosis by Hounsfield units of 58.51%, the sensitivity of 93.26% and specificity of 90.22%, without a statistically significant difference concerning DXA ($p = 0.07$).

About the complications associated with the diagnosis of osteoporosis made by Hounsfield Units by tomography, the prevalence of these is 24.55%, with a sensitivity of 43.37% and specificity of 94.65%, and a $p = 0.6$, without a significant statistical relationship concerning the relationship between the diagnosis of osteoporosis by HU and the risk of complications in this regard.

About screw loosening in spinal surgery and the diagnosis of osteoporosis by Hounsfield Units, the prevalence of loosening was estimated at 82.31%, with low sensitivity (6.16%) and high specificity (77.53%) and a $p = 0.02$, which demonstrates a statistically significant relationship between the diagnosis of osteoporosis by HU and the risk of screw loosening.

Study limitations.

1. HU value is not the perfect tool for diagnosing osteoporosis; this comparison is a surrogate measure.
2. HU measurement is impossible in the following situations: fracture, spondylitis, and osteosynthesis material.
3. The results of this study do not provide evidence regarding the cervical and thoracic spine.
4. The cancellous tissue is not homogeneous; the examination of the medial axial section may not accurately represent the quality of the bone.
5. HU measurements included only cancellous bone density; T-score measures cancellous bone and cortical bone.
6. Retrospective review, selection bias, and confounding factors.
7. Heterogeneity of the population.
8. The studies reviewed were retrospective with moderate to low level of evidence.
9. Relatively smaller number of patients.

CONCLUSIONS

The measurement of HU for the diagnoses of osteoporosis results to be more sensitive, specific and predictive compared with DEXA, mainly in elderly patients; it represents a useful tool for planning spinal surgery, minimizing the complications risks such as screw loosening, fractures, pseudoarthrosis, subsidence of intrabody devices and proximal junctional kyphosis.

Prospective studies with a larger casuistry are required to verify the mentioned data and to determine the possibility of excluding DEXA as a diagnosis of osteoporosis.

At the moment, the results do not allow a significant recommendation of the use of Hounsfield Units over the use of DXA, for the diagnosis of osteoporosis in the general population, as well as an evaluation of the usefulness in surgical planning and prevention of post-surgical complications, except for the significant relationship between screw loosening in spinal surgery in osteoporosis diagnosed by HU; the recommendations by the different authors define the possibility of the alternative use of the system in specific circumstances. Studies with more substantial evidence and complexity are required to complement these concepts, allowing a higher degree of recommendation.

A protocol has not been developed for the subject of the study.

All authors declare no potential conflict of interest related to this article.

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