Palestrica of the third millennium – Civilization and Sport
Vol. 15, no. 1, January-March 2014, 11–15

ORIGINAL STUDIES
ARTICOLE ORIGINALE

Correlation of periprosthetic bone mineral density and skeletal bone mineral density values in patients with total hip arthroplasty

Corelaţia valorilor densităţii mineral osoase periprotetice cu densitatea mineral osoasă a întregului schelet la pacienţii cu artroplastie totală coxofemurală

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Abstract

Background. The presence of periprosthetic osteoporosis influences the postoperative evolution of hip replacement patients, delays the functional rehabilitation process and considerably decreases the quality of life of these patients.

Aims. The aim of the study is to demonstrate the role of periprosthetic bone mineral density (BMD) and to correlate its values with skeletal (BMD) values.

Methods. The study was carried out at the Clinical Rehabilitation Hospital Cluj-Napoca in the period June-December 2009, on 58 patients aged between 30-83 years with uni- and bilateral cemented and uncemented total hip endoprostheses. For the determination of the bone mineral density, the dual X-ray absorptiometry (DXA) method was used, with the software for orthopedic prostheses available.

Results. Statistical data analysis demonstrated a direct correlation between periprosthetic (BMD) and skeletal bone mineral density values, without 100% overlapping, which requires the presence of reference values for periprosthetic areas.

Conclusions. Although it follows the tendency of skeletal (BMD), periprosthetic bone mineral density requires T scores specific for the periprosthetic Gruen zones.

Key words: bone mineral density, periprosthetic osteoporosis, hip endoprosthesis.

Rezumat

Premize. Prezenţa osteoporozei periprotetice influenţează evoluţia postoperatorie a pacienţilor endoprotezaţi, întârzie procesul de recuperare funcţională şi scade considerabil calitatea vieţii acestor pacienţi.

Obiective. Obiectivul studiului este de a demonstra rolul densităţii mineral osoase (DMO) periprotetice şi de a corela valorile acesteia cu valorile DMO ale întregului schelet.

Metode. Studiul s-a desfăşurat în cadrul Spitalului Clinic de Recuperare Cluj-Napoca, în perioada iunie-decembrie 2009, fiind incluşi un număr de 58 de pacienţi, cu vârsta cuprinsă între 30-83 ani, cu endoproteze totale de şold cimentate şi necimentate, uni- şi bilaterale. Pentru determinarea densităţii mineral osoase s-a folosit metoda absorpţiometriei bifotonice cu raze X (DXA), având la dispoziţie software-ul pentru proteze ortopedice.

Rezultate. Analiza statistică a datelor a demonstrat o corelaţie directă între valorile DMO periprotetice şi cele ale întregului schelet, fără a exista o suprapunere de 100%, ceea ce face necesară existenţa unor valori de referinţă pentru zonele periprotetice.

Concluzii. Densitatea mineral osoasă periprotetică, deşi urmează tendinţa DMO a întregului schelet, impune existenţa unor scoruri T specifice zonelor periprotetice Gruen.

Cuvinte cheie: densitate mineral osoasă, osteoporoza periprotetică, endoproteze de şold.

Received: 2014, February 26; *Accepted for publication:* 2014, March 10;
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Introduction

The World Health Organization considers osteoporosis as one of the major diseases of the modern period, the consequence of a certain lifestyle (diet, physical exercise), which places an important burden on the community and is continuously increasing with the increase of the proportion of the elderly in the population. Data provided by WHO show that if in 1960 the number of people aged over 60 years was 250 million, by 2020 it will reach about 1 billion (Glowacki et al., 2003).

This general population aging tendency has occurred on the background of an increase of life expectancy in developed countries, which is 80 years for women. Since the menopause onset age remains the same (around 50 years), more than 30% of a woman's life is postmenopausal (Jones et.al., 2005).

Osteoporosis is a systemic disease characterized by low bone mass and the alteration of bone microarchitecture, resulting in increased bone fragility and fractures.

The diagnostic threshold of -2.5 SD identifies osteoporosis in 15-30% of postmenopausal women (Harty et.al., 2005). Studies have demonstrated that osteoporosis is an underdiagnosed and undertreated disease: it is estimated that there are currently more than 150 million people worldwide who suffer from osteoporosis, and after the age of 50 years, 40% of women and 13% of men develop at least one osteoporotic fracture (Delisa, 2005; Mihailov & Cevei, 2006; Feldstein et al., 2003). The literature emphasizes that the risk of a hip fracture during a woman's life is higher than the risk of breast, endometrial and ovarian cancer together (Harvey et al., 2010).

Patients who had a previous vertebral fracture have a 4 times higher risk to develop another vertebral fracture compared to the general population. The most common location of vertebral fractures is at the thoracolumbar junction and in the middle thoracic area (Vissers et.al., 2011). Patients with prevalent vertebral fractures also have a two times higher risk of hip fractures compared to the general population (Harvey et al., 2010; Boonen & Singer, 2008). The number of hip fractures worldwide is estimated to increase from 1.66 million in 1990 to 6.26 million in 2050. Over the next 50 years, the number of osteoporotic fractures will double (Rodaro et al., 2004).

In the United States of America, about 13.8 billion dollars are spent every year for the treatment of osteoporotic fractures and the costs continue to increase. Therefore, the efforts made in order to develop a coherent and sustained strategy for the prevention, early detection and treatment of osteoporosis are easy to understand (Harvey et al., 2010).

Prevention in osteoporosis remains extremely important, as long as there is practically no method for restoring the quality of bone affected by osteoporosis (Watts et. al., 2011).

Osteoporosis is a classical example of disease that is easier to prevent than to treat, because the results of treatment are various and unpredictable. The most promising prophylactic tendencies are represented by the attempts to reach maximal skeletal bone mass (Sànchez-Rieraet al., 2010; Cooper et al., 2011).

Hypothesis

The aim of the study is to correlate periprosthetic bone mineral density and skeletal bone mineral density values and to obtain cut-off values for the seven Gruen zones, for which there is currently no T score.

Materials and Methods

We mention that according to the Helsinki Declaration, Amsterdam Protocol and the Directive 86/609/EEC, there is the approvement of Ethical Commission from the University of Medicine and Pharmacy „Iuliu Haţieganu" Cluj-Napoca.

Research protocol

Period and place of the research

The study was carried out in the medical rehabilitation service of the Clinical Rehabilitation Hospital Cluj-Napoca, in the period June-December 2009.

Subjects and groups

Was included 58 patients, 22 males and 36 females, aged between 30-83 years with uni- and bilateral cemented and uncemented total hip endoprostheses.

Tests applied

Bone mineral density was determined by the dual X-ray absorptiometry (DXA) method, with the Lunar Prodigy Advance osteodensitometer, using the en. Core 11.x software and computers with the Windows XP Professional operating system.

Bone mineral density was measured at vertebral and bilateral femoral level, with the software for orthopedic prostheses available. Using this software, the osteodensitometer recognizes the existing prosthesis, differentiating bone tissue from the prosthetic material; thus, the bone density level is the real one.

The device allows to measure the bone mineral content BMC (grams) and bone mineral density BMD (grams/cm²), in seven different periprosthetic areas known as the Gruen zones.

Inside the seven Gruen zones (RM), seven small periprosthetic areas (rm) of 0.5/1 cm were selected (each RM zone having a corresponding small rm zone), in order to evidence periprosthetic bone loss.

The 7 periprosthetic Gruen zones (RM) and the small areas corresponding to the Gruen zones (rm) in the replaced hip are represented in Figures 1 and 2.

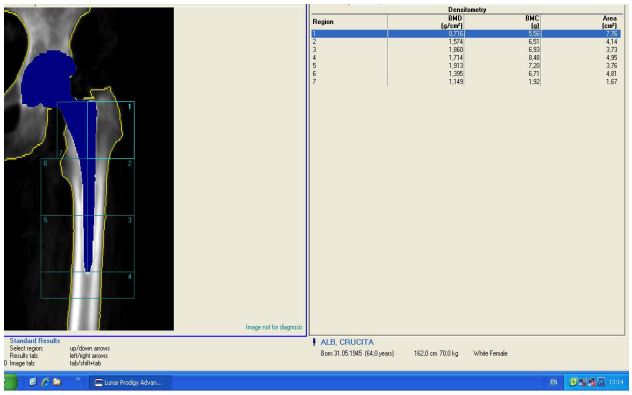

Fig. 1 – Gruen zones in the replaced hip

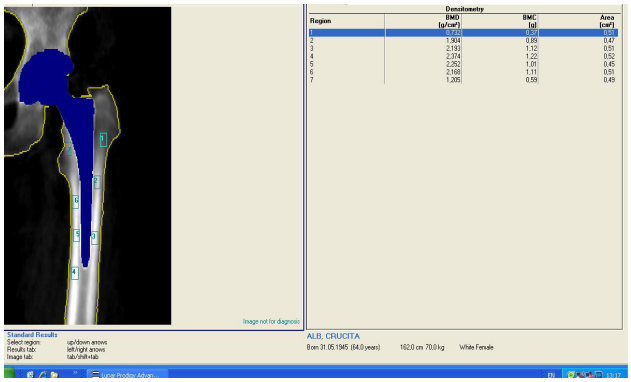

Fig. 2 – Small areas corresponding to the Gruen zones in the replaced hip

According to WHO criteria, osteoporosis is defined as a T score lower than or equal to -2.5 SD; in the case of osteopenia, T score values range between -1.5 and -2.5 SD; T score is the standard for the interpretation of results.

For diagnosis, T scores at vertebral level and at the level of the hip contralateral to the replaced hip were used in the case of unilateral arthroplasty, and only at vertebral level in the case of bilateral endoprostheses, as there were no reference values for the replaced hip.

T score values along the vertical axis to the right indicate the standard derivations of the BMD of a patient compared to the bone mineral density of a young adult (Fig. 3).

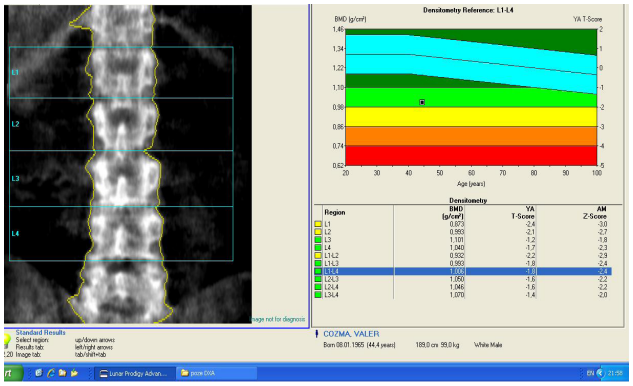

Fig. 3 – Reference diagram

Statistical processing

In order to determine the cut-off value, in the case of a quantitative variable in a significant relationship with a qualitative variable, the method of the ROC (Receiver operating characteristic) curves was used. The cut-off value found was verified by testing the relationship with the qualitative variable.

Statistical calculations were performed using the SPSS 13.0 and Microsoft EXCEL applications.

Results

The mean bone mineral density values were statistically significantly lower in the case of the replaced hip both for the Gruen zones (p=0.02) and the small areas corresponding to the seven Gruen zones (p=0.01) (Figures 4, 5).

The mean BMD values of the seven periprosthetic zones were statistically significantly lower (p<0.05) in the case of the diagnosis of osteoporosis compared to osteopenia, and lower in the case of osteopenia compared to normal BMD, both for the Gruen zones and for the small areas corresponding to the Gruen zones (Figures 4, 5).

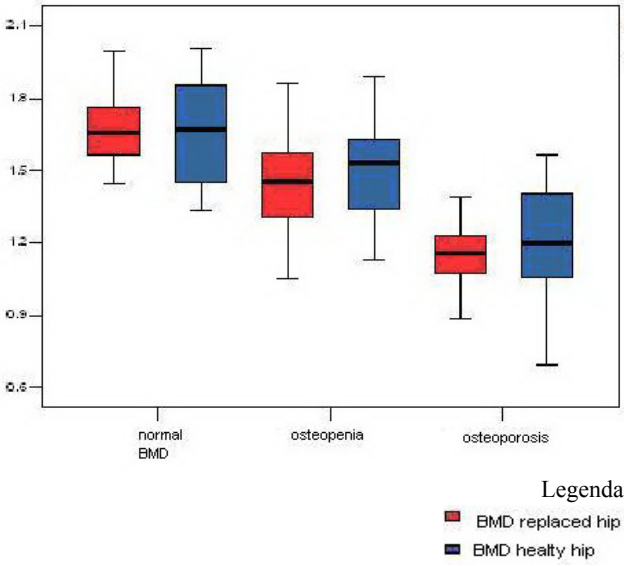

Fig. 4 – Comparison between the mean BMD of the 7 Gruen zones (RM) depending on the diagnosis made by DXA, in the two hips

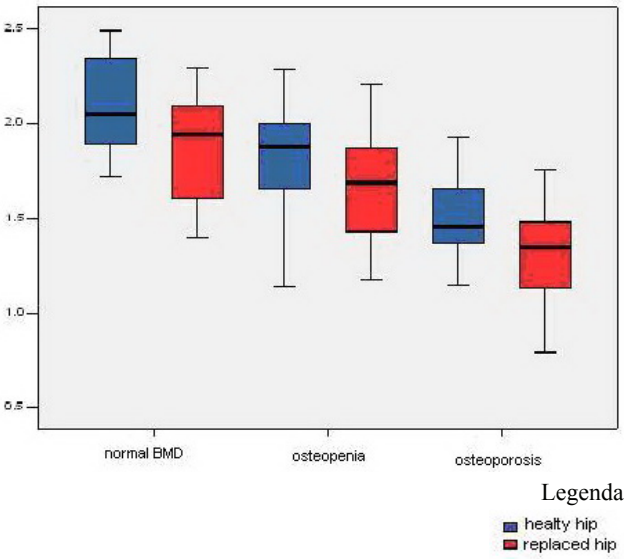

Fig. 5 – Comparison between the mean BMD of the small areas corresponding to the Gruen zones (rm) depending on the diagnosis made by DXA, in the two hips

Subsequently, we tried to obtain BMD cut-off values for the seven periprosthetic zones (without having a T score for these zones) in the studied patients with different diagnoses (normal BMD/osteopenia/osteoporosis), using the T score for the healthy contralateral hip.

The statistical procedure used was represented by the ROC curves; the area under the curve proved to be statistically different from the area under the diagonal, so that cut-off values could be determined.

The cut-off values found for the BMD of the

periprosthetic areas were 1.6 and 1.24 for the Gruen zones; 1.98 and 1.68 for the small areas corresponding to the Gruen zones.

Interpretation of these results for the Gruen zones: if the mean BMD was higher than 1.6, the patient was probably diagnosed with normal BMD; if the mean BMD was lower than 1.6 and higher than 1.24, the patient was probably diagnosed with osteopenia; if the mean BMD was lower than 1.24, the patient was probably diagnosed with osteoporosis.

For the small areas corresponding to the Gruen zones, we interpreted the results in accordance with the values obtained: if the mean BMD was higher than 1.98, the patient was probably diagnosed with normal BMD; if the mean BMD was lower than 1.98 and higher than 1.68, the patient was probably diagnosed with osteopenia; if the mean BMD was lower than 1.68, the patient was probably diagnosed with osteoporosis.

The cut-off values were verified for the healthy hip with the contingency table I (Table I) for the Gruen zones and the contingency table II (Table II) for the small areas corresponding to the Gruen zones.

The results of the verification for the Gruen zones were as follows: 11 of the 16 patients diagnosed with normal BMD were classified as normal based on the BMD values of the periprosthetic zones, 17 of the 24 patients diagnosed with osteopenia were classified as osteopenic based on the BMD values of the periprosthetic zones, 14 of the 18 patients diagnosed with osteoporosis were classified as osteoporotic based on the BMD values of the periprosthetic zones. The other patients were misclassified. The accuracy of the classification using the BMD cut-off values of the periprosthetic zones was 72.41% (representing the number of correctly classified patients of all patients based on periprosthetic BMD).

Table I

Classification of patients using the BMD cut-off values of the periprosthetic Gruen zones

Values	BMD	normal	osteopenia	osteoporosis	Total
Cut-off	normal	11	4	0	15
	osteopenia	5	17	4	26
	osteoporosis	0	3	14	17
Total		16	24	18	58

The results of the verification for the small areas corresponding to the Gruen zones were as follows: 11 of the 16 patients diagnosed with normal BMD were classified as normal based on the BMD values of the periprosthetic zones, 12 of the 24 patients diagnosed with osteopenia were classified as osteopenic based on the BMD of the periprosthetic zones, 15 of the 18 patients diagnosed with osteoporosis were classified as osteoporotic based on the BMD values of the periprosthetic zones.

The other patients were misclassified. The accuracy of the classification using the BMD cut-off values of the periprosthetic zones was 65.52%.

Table II

Classification of patients using the BMD cut-off values of the small areas corresponding to the Gruen zones

Values	BMD	normal	osteopenia	osteoporosis	Total
Cut-off	normal	11	6	0	17
	osteopenia	5	12	3	20
	osteoporosis	0	6	15	21
Total		16	24	18	58

The comparison of the healthy hip and the replaced hip evidenced the following results for the Gruen zones:

- 3 of the 15 patients considered to have normal BMD in the healthy hip were considered to have osteopenia in the replaced hip;
- 3 of the 26 patients considered to have osteopenia in the healthy hip were considered to have osteoporosis in the replaced hip;
- 6 of the 26 patients considered to have osteopenia in the healthy hip were considered to have normal BMD in the replaced hip;
- 8 of the 17 patients considered to have osteoporosis in the healthy hip were considered to have osteopenia in the replaced hip (Table III).

Table III

Comparison between the two hips depending on the BMD cut-off values of the Gruen zones

		Healthy hip			Total
Replaced hip	BMD	normal	osteopenia	osteoporosis	
	normal	12	6	0	18
	osteopenia	3	17	8	28
	osteoporosis	0	3	9	12
Total		15	26	17	58

La compararea şoldului fără ETS cu şoldul endoprotezat, pentru zonele mici corespondente zonelor Gruen, au fost obţinute următoarele rezultate:

The comparison of the healthy hip and the replaced hip evidenced the following results for the small areas corresponding to the Gruen zones:

- 5 of the 17 patients considered to have normal BMD in the healthy hip were considered to have osteopenia in the replaced hip;
- 3 of the 17 patients considered to have normal BMD in the healthy hip were considered to have osteoporosis in the replaced hip;
- 11 of the 20 patients considered to have osteopenia in the healthy hip were considered to have osteoporosis in the replaced hip (Table IV).

Table IV

Comparison between the two hips depending on the BMD cut-off values of the small areas corresponding to the Gruen zones

		Healthy hip			Total
Replaced hip	BMD	normal	osteopenia	osteoporosis	
	normal	9	0	0	9
	osteopenia	5	9	0	14
	osteoporosis	3	11	21	35
Total		15	17	20	21

Discussion

The knowledge of reference values, i.e. T scores for periprosthetic bone mineral density, would better evidence periprosthetic bone mass loss, allowing for an optimal therapeutic approach, at the most appropriate time for the patient (Smolders et al., 2010, Cushnaghan et.al., 2007).

The life duration of an endoprosthesis depends on a number of factors, and periprosthetic bone mineral density is one of the most important; thus, the knowledge of the densitometric values of the Gruen zones becomes extremely important, even before the making of a diagnosis of low skeletal BMD (osteopenia/osteoporosis) according to WHO criteria is possible (Hakulinen et al., 2010).

Knowing these aspects will enable an effective therapeutic approach of the rehabilitation of patients with hip arthroplasty, creating the premises for a normal hip functionality and for an optimal performance of domestic, professional and sports activities by the patients.

The results obtained, the accuracy of 72.41% for the Gruen zones and 65.52% for the small areas corresponding to the Gruen zones, oblige us to perform further studies in order to establish reference values for these areas, given that the proportion of misclassified patients based on the reference values for the other areas (the spine and the healthy contralateral hip) is rather high.

The mean periprosthetic BMD values were lower in the case of osteoporosis compared to osteopenia, and lower in the case of osteopenia compared to normal skeletal BMD.

Conclusions

1. The replaced hip has statistically significantly lower mean periprosthetic BMD values compared to the contralateral hip.

2. The degree of bone mineralization in the replaced hip is correlated with the diagnosis of normal BMD/ osteopenia/osteoporosis of the entire skeleton.

3. The BMD value of the periprosthetic Gruen zones better coincides with the diagnosis made based on the T score in the healthy hip (compared to the small areas corresponding to the Gruen areas).

4. Reference values for periprosthetic bone mineral density are needed.

Conflict of interests

Nothing to declare.

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