Summary

Introduction. Osteoporosis is the most frequent metabolic disease of bones. Early detection of pathological loss of bone mineral density represents the first step in prevention, treatment and rehabilitation of osteoporosis. This study was aimed at establishing the correlation of T-score values obtained by ultrasound osteodensitometry of calcaneus with dual-energy x-ray absorptiometry scan. 

Material and Methods. The study was conducted on the sample of 569 female patients from September 13, 2010 to March 10, 2011. Measurement was made with ultrasound osteodensitometry of ACHILLES make. Quantitative ultrasound method revealed that 77 female patients had a lower value of T-score (osteopenia with risk factors or osteoporosis) and they were referred to T-score measurement with dual-energy x-ray absorptiometry scan. Dual-energy x-ray absorptiometry scanning was performed using LUNAR DPX scanner and 49 female patients were examined.

Results. It was concluded that there was no statistically significant difference between T-score values obtained by quantitative ultrasound and dual-energy x-ray absorptiometry scanning.

Conclusion. According to this study, it is necessary to provide a greater number of scanners for ultrasound osteodensitometry of calcaneus in order to secure prevention and to refer the patients to further diagnosing on time.

Key words: Osteoporosis; Bone Diseases, Metabolic; Bone Density; Calcaneus; Absorptiometry, Photon; Risk Factors; Questionnaires; Female; Bone and Bones + ultrasonography

Introduction

According to the definition obtained at the Consensus Development Conference from 1993 “osteoporosis is a progressive, system and metabolic condition of bones in which the bones become brittle thereby increasing bone fragility which, as a result, has an increased risk of bone fractures” [1]. Osteoporosis is the most frequent bone disease. The severity of the problem is aggravated by its frequency among the world population. About 75 million people in Europe, United States of America and Japan are affected. Women over 45 years of age spend more
WHO – World Health Organization
QUS – quantitative ultrasound
BMD – bone mineral density measurement
DEXA – dual-energy x-ray absorptiometry
BMI – body mass index
OP – osteoporosis
P – osteopenia
days in hospital because of osteoporosis than because of many other diseases including diabetes, acute myocardial infarction and a breast cancer. In the world, less than 1/3 of patients are diagnosed to have this disease and only 1/7 of the patients are medically treated.

According to the estimation made by Bureau of Statistics from 2013, there are 320,957 women over 50 in the Republic of Srpska. According to data obtained from the World Health Organization (WHO), 30% of the total number of women have osteoporosis [2] so the expected number of persons with osteoporosis in the Republic of Srpska is about 96,287.

It has been estimated that about 375,000 women in Serbia suffer from osteoporosis. Only 30% of that number are medically treated. Early detection of pathological loss of bone mineral density represents the first step in prevention, treatment and rehabilitation of osteoporosis.

Anamnesis, a detailed clinical examination with the distinction between high and low risk factors as well as the quantitative ultrasound (QUS) make it possible to recognize the persons at an increased risk for osteoporosis and to refer them to the bone mineral density measurement (BMD) with double exposition with x-rays by dual-energy x-ray absorptiometry (DEXA) method.

The results of bone density measurement may be expressed as a deviation, number of standard deviations from the medium bone density in young healthy people and is expressed as T-score. This value shows how much the real bone density is different from the standard bone density of the young, healthy people that serves as the basic value. The values of T-score mark:

- normal bone density – if the T-score values are between +1.0 and -1.0 SD from normal values,
- osteopenia – if the T-score value is between -1.0 and -2.5 SD from normal values,
- osteoporosis – if the T-score value is -2.5 SD or less than normal values,
- major osteoporosis – if the T-score value is -2.5 SD from normal value and if there is a bone fracture, at the same time.

The aforementioned criteria have been recommended by the WHO [3]. Anamnesis, risk factor analysis, a detailed clinical examination and QUS enable timely detection of patients at increased risk for osteoporosis and thereby reduction of unnecessary expenses of diagnostics and treatment of possible complications [4].

This study was aimed at establishing the correlation of T-score values obtained by ultrasound osteodensitometry of heel bone and by DEXA measurement.

**Material and Methods**

The research was conducted at the General Hospital “Saint Apostle Luke” in Doboj and at Special Hospital for Rehabilitation after Cardiovascular Diseases Banja Vrućica, Tesla in the period from September 13, 2010 to March 10, 2011 and mineral density on heel bone was examined by ultrasound osteodensitometry in 569 women. Measurement was done in the form of epidemiological research on osteoporosis representation in women from the region of Doboj. Research was conducted by ACHILLES ultrasound osteodensitometry at the General Hospital “Saint Apostle Luke” Doboj. The authors used questionnaires on risk factors for osteoporosis containing various questions such as body weight and height, body mass index (BMI) (which was calculated as per standard formula), menarche, menopause, family anamnesis for osteoporosis, data on earlier fractures, existence of chronic diseases and the use of drugs indicated as risk factors for osteoporosis, as

| Table 1. Results of QUS measurement and patients who had undergone DEXA measurement |
| Tabela 1. Rezultati QUS merenja i pacijentkinje koje su uradile merenje metodom dvostruke apsorpciometrije X-zraka |
| Results of QUS measurements/Rezultati QUS merenja | Frequency/Učestalost | Percent/Procenat |
| Total/Ukupno | 569 | 100% |
| Normal finding/Uredan nalaz | 492 | 86,5% |

| Referred to DEXA/Upućeno na DEXA | Frequency/Učestalost | Percent/Procenat |
| Total/Ukupno | 77 | |
| Osteopenia+RF | 58 | 13,5% | 75,3% |
| Osteoporosis | 19 | 24,7% | Osteoporosis |

| Underwent DEXA measurements/Uradile DEXA merenje | Frequency/Učestalost | Percent/Procenat |
| YES/Da | 49 | | |
| Osteopenia+RF | 32 | 63,6% | 65,3% |
| Osteoporosis | 17 | 34,7% | Osteoporosis |

| NO/Ne | 28 | 36,4% |

*QUS - utrazvučna osteodenzitometrija; *DEXA - dvostruka ekspozicija x zracima
well as coffee and cigarettes consumption, nutrition and physical activity.

Of the interviewed patients, a sample of 77 (13.5%) was made of those who were diagnosed to have osteopenia with risk factor or osteoporosis.

Out of 77 patients, 49 (63.6%) were tested by DEXA method. The examination was done on the lumbar discs and hip with LUNAR DPX at the Special Hospital for Rehabilitation after Cardiovascular Diseases, Banja Vrucica, Teslic.

Based on results obtained by measuring the bone mineral density, all patients who were diagnosed to have osteopenia with the presence of risk factors or osteoporosis were divided into two groups. The first group consisted of patients with osteopenia with the presence of risk factors and the second group consisted of patients with osteoporosis (according to the criteria for osteoporosis defined by the WHO/International Osteoporosis Foundation), whereas the examinees with normal medical findings were excluded from further testing.

The study results have been represented by frequencies, arithmetic average, standard deviation, range of maximum and minimal value. X² test was used to determine the statistical significance and contingency coefficient (C) and Pearson’s correlation coefficient (R) were used to assess the intensity of correlation.

Results

The study was conducted from September 13, 2010 to March 10, 2011 and included a sample of 569 patients between 25 and 86 years of age. The patients were classified into age groups, as illustrated in the Graph 1.

The value of T-score was above -1 SD in 492 (86.5%) patients, that being a normal finding; whereas in 77 (13.5%) patients a lower value of T-score was found, in 19 of them (24.7%) the value of T-score was in the range of osteopenia with the presence of risk factor, whereas 58 (75.3%) of patients were diagnosed to have osteoporosis by QUS testing. All patients with such medical findings were recommended to undergo further diagnostics by DEXA method. Of 77 patients referred to DEXA testing, 49 (63.6%) did the testing, whereas 28 (36.4%) patients (2 with osteopenia and 26 with osteoporosis) did not undergo further testing (Table 1).

T-score values, which were above -2.5 SD with the presence of risk factor, were in the range of osteopenia (P) in 17 (34.7%) patients, and in 32 (65.3%) patients, T-score value which was obtained by ultrasound osteodensitometry indicated osteoporosis (OP) (Table 2).

After DEXA testing, T-score values were within the limits of osteopenia (P) in 26 (53.1%) examinees, osteoporosis (OP) was diagnosed in 21 (42.9%) patients and 2 (4.1%) patients had normal medical findings (Table 3).

A contingency table was created for the sample of examinees diagnosed to have osteopenia after QUS testing, with the presence of risk factor (19) or osteoporosis (58) including also those who were not

---

Table 2. Distribution of osteopenia (P) and osteoporosis (OP) in QUS measurements

<table>
<thead>
<tr>
<th></th>
<th>Frequency/Učestalost</th>
<th>Percent</th>
<th>Cumulative/Kumulativno</th>
<th>Percent/Procent</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>17</td>
<td>34.7</td>
<td>34.7</td>
<td></td>
</tr>
<tr>
<td>OP</td>
<td>32</td>
<td>65.3</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>Total/Ukupno</td>
<td>49</td>
<td>100.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Distribution of osteopenia (P) and osteoporosis (OP) on DEXA measurements

<table>
<thead>
<tr>
<th></th>
<th>Frequency/Učestalost</th>
<th>Percent</th>
<th>Cumulative Percent/Kumulativno procenat</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>26</td>
<td>53.1</td>
<td>53.1</td>
</tr>
<tr>
<td>OP</td>
<td>21</td>
<td>42.9</td>
<td>95.9</td>
</tr>
<tr>
<td>normal finding</td>
<td>nalaz uredan</td>
<td>2</td>
<td>4.1</td>
</tr>
<tr>
<td>Total/Ukupno</td>
<td>49</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

*DEXA - dvostruka ekspozicija x zracima
tested by DEXA method (28 of them) and χ² test was calculated. The calculated value of χ² test was 7.55 with the number of degrees of freedom df = 3 for the significance level of 0.05. The limiting value Xg² equaled 7.81 for level of significance and number of degrees of freedom. Since χ² was < Xg² (7.55 < 7.81) and p was >0.05, the hypothesis was accepted that there was no statistically significant difference between T-score testing with QUS and DEXA method, even if the fact that 36.4% of patients did not undergo DEXA test is taken into consideration.

However, it should be said that the above mentioned value of χ² test was on the significance borderline (p=0.056).

Accordingly, the contingency coefficient (C) was somewhat larger C=0.299; so, there was a moderate contingency between two measurements as well as a moderate positive correlation between the two.

Discussion

Osteoporosis is a medical condition characteristic for women. In addition to postmenopausal osteoporosis, our earlier research from 2009 showed that a large number of women had low values of T-score in premenopausal period as a result of the presence of a great number of risk factors that being the reason why our research was not limited to the women in menopause only [5].

In order to avoid side effects, osteoporosis fractures, osteoporosis must be diagnosed on time. An early diagnosis and timely beginning of medical treatment are of extreme importance especially in persons having one or several factors for disease.

Ultrasound osteodensitometry (quantitative ultrasound QUS) is one of screening tests. It has been developed intensively over years and it is based on measurement of decreased intensity of ultrasound wave when going through the bone tissue (when measured on the heel bone) or on measurement of change of speed of ultrasound wave along the bone (tibia) [1]. Ultrasound screening of the heel, i.e. the examination made by ultrasound densitometry is a relatively fast (few seconds) and comfortable (it is not necessary to take off clothes) and it is done on the heel bone. Ultrasound densitometry measures the peripheral bone density and this method may point out to a higher risk of fracture. In cases of extremely evident osteoporosis assessed by ultrasound densitometry followed by a fracture, it is necessary to do DEXA verification as well [6].

The study, which was performed in the period of 6 months, from September 13, 2010 to March 10, 2011, included 569 patients between 25 and 86 years of age.

All patients filled in the questionnaire on the presence of risk factor for osteoporosis. The questionnaire contained questions about the patients’ age, menarche, menopause, body height, weight, (whereby BMI was calculated), presence of earlier fractures, family anamnesis for osteoporosis, presence of diseases associated with osteoporosis, administration of drugs that may cause decrease of bone density and data on smoking, coffee consuming, nutrition and physical activity. Bone density was measured in all patients with ACHILLES ultrasound osteodensitometer.

Out of the total number of patients, 492 (86.5%) had T-score value above -1 SD, that being a normal finding, whereas T-score value was lower in 77 (13.5%) patients, and the obtained value of T-score was within the range of osteopenia with the presence of risk factor in 19 patients (24.7%), whereas 58 (75.3%) patients were diagnosed to have osteoporosis by QUS measurement. All patients with such diagnosis were recommended to undergo further diagnostics with DEXA method. Criteria for patients’ referral to DEXA measurement were set in accordance with the Guidelines for prevention, diagnostics and osteoporosis treatment drafted by the Association for Osteoporosis of Republic of Srpska in May 2009 [7].

Out of 77 patients referred to DEXA measurement, 49 (63.6%) were examined. Further diagnostics was not recommended to 28 patients (36.4%), 2 (2.6%) of them having osteopenia and 26 (33.8%) having osteoporosis. It is considered that every third woman having osteoporosis does not take a proper care of her bones [8]. Our research has confirmed such an attitude of women towards osteoporosis diagnostics as well.

A distinction must be made between decreased bone density retaining the adequate architecture of bone tissue and normal geometry and density of the tissue. According to the definition made by Harold Frost, the former is called osteopenia, and the latter is osteoporosis. In other words, Frost claims that the difference between osteoporosis and osteopenia is not only a quantitative one but a qualitative one as well. According to the definition made by the WHO/International Osteoporosis Foundation, osteopenia is defined by T-score values ranging from -1.0 to -2.5 SD [9].

It has been understood that parameters of ultrasound testing may serve for the evaluation of bone density and quality and they are independent predictors of risk of bone fracture.

Diagnosis of osteoporosis depends on the analysis of specific locations (spine, hip) and ultrasound osteodensitometry is of great significance in primary osteoporosis diagnostics. It has been recommended that all patients at risk should be referred to ultrasound osteodensitometry of heel bone in order to detect a risk of bone fracture and osteoporosis on time and then for further treatment and DEXA measurement in accordance with the WHO guidelines [10].

In 17 (34.7%) patients who underwent DEXA measurement, the T-score value was within the osteopenia range, being above -2.5 SD with the presence of risk factors. The T-score value obtained by ultrasound osteodensitometry indicated osteoporosis in 32 (65.3%) patients.
After DEXA measurement, the T-score value was within osteopenia range in 26 (53.1%) patients and osteoporosis was diagnosed in 21 (42.9%) patients, whereas 2 patients (4.1%) had normal findings.

Experience gained so far on the use of quantitative ultrasound is contradictory. El Desoukimi has concluded that by applying the current methods of determining T-score value, quantitative ultrasound cannot be used as a screening method and that it is necessary to make some modifications of T-score values [11].

Pfister et al. made similar conclusions by comparing T-score values obtained by quantitative ultrasound of the heel bone and by DEXA measurement in the patients with hip fracture. They found that the sensitivity and specificity of quantitative ultrasound as a technology was 58% and 80%, respectively.

In the detection of osteopenia and osteoporosis of the hip, quantitative ultrasound of the heel failed to diagnose 37% of patients with abnormal values of the T-score obtained by DEXA measurement [12]. Van den Bergh et al. agree that there is no consensus on osteoporosis diagnostics by quantitative ultrasound of a heel bone. They have proved that quantitative ultrasound may assess a risk of fracture in women aged 65 or older. Currently, there are significant differences between ultrasound devices and there is no standardization. It is necessary to develop the quality standards and intercrossed calibration for quantitative ultrasound devices in order to compare the results obtained by different devices. Standardization is necessary for DEXA osteodensitometers [13]. Gojković stresses that nowadays there is a huge number of devices of various manufacturers used for DEXA measurement. Various devices used for BMD measurement as well as results are such that it is impossible to compare findings obtained with different devices without previous existence of intercrossed calibration in spite of applying the same technology [14].

Van den Bergh has confirmed the results obtained by El-Desoukimi and Pfister that although a quantitative ultrasound of a heel bone is a promising method for the evaluation of osteoporosis fractures, its routine application in clinical practice is still not applicable [13]. On the other hand, research conducted by Lappa et al. has shown that ultrasound parameters are well correlated with BMD of hip and biochemical markers of bone structure in elderly women. Ultrasound measurement may be used as a screening test of the bone status in women of the third age or those living in rural areas where DEXA and biochemical laboratories are less likely to be available [15].

Quantitative ultrasound with the method of self-calculation of osteoporosis risk (OST) is a significant one in detecting population at high risk for osteoporosis which may be an alternative method for osteoporosis diagnostics, especially in regions in which DEXA measurement is not available, as stressed in the paper by Zha et al. [16].

QUS method is also significant for monitoring women over 65 years of age who were found to have normal values of T-score or osteopenia with QUS method thus preventing progression towards osteoporosis, which, according to Goulay et al., developed in women with mild osteopenia (T-score values -1.49 to -1 SD) after 15 years, in women with moderate osteopenia (T-score values -1.99 to -1.5 SD) after 5 years, and in women with severe osteopenia (T-score values -2.49 to -2 SD) after a year [17].

On the other hand, Doshi et al. believe that besides T-score values, clinical risk factors must be taken into consideration when assessing the progression of osteopenia towards osteoporosis [18].

Our study results show that there is no statistically significant difference between T-score measurement by QUS and DEXA method, even if we take into consideration the fact that 36.4% of the patients did not undergo DEXA measurement. However, it is essential that the aforementioned value of the X² test was on the significance level (p=0.056).

Along with clinical examination and blood tests, DEXA represents the “gold standard” when making diagnosis of osteoporosis. However, the classification of patients based only on T-score filters almost half of the patients with clinical diagnosis of osteoporosis [14].

Osteoporosis diagnosis has been improved significantly by complementing BMD findings with vertebral fracture assessment (VFA), micro-architecture estimation (TBS) and fracture risk assessment tool (FRAX) which can be installed on the existing DEXA devices and it is possible to calculate a ten-year risk for fracture and identify patients with osteoporosis and high fracture risk [14]. However, these techniques are still not available to us. Quantitative ultrasound is a safe, easy-to-handle, x-ray free, mobile and economic auxiliary tool for diagnostics.

In comparison with “gold standard” DEXA measurement, quantitative ultrasound used by Schnabel has proved to have the same capability to filter the patients in menopause with proximal femur fracture from the healthy ones. Schnabel believes that quantitative ultrasound may be a useful and valuable technique in clinical practice which has been confirmed by our research as well [19].

**Conclusion**

This study has shown that there is no statistically significant difference between T-score values obtained by quantitative ultrasound and those obtained by dual-energy x-ray absorptiometry measurement. Dual-energy x-ray absorptiometry, along with clinical examination and blood tests, represents the “gold standard” in diagnosing osteoporosis.

Osteoporosis diagnosis has been improved significantly by complementing bone mineral density measurement findings with vertebral fracture assessment, micro-architecture estimation and fracture risk assessment tool which can be installed on
the existing dual-energy x-ray absorptiometry devices and it is possible to calculate a ten-year risk for fracture and identify patients with osteoporosis and high fracture risk. However, these techniques are still unavailable in this area.

In line with standards set by European Union, 11 dual-energy x-ray absorptiometry devices should be provided per 1 million of population. Republic of Srpska has the population of 1,326,991. There are 10 dual-energy x-ray absorptiometry devices in Republic of Srpska and only 3 dual-energy x-ray absorptiometry devices are available to the patients through the Health Insurance Fund.

Based on the study results, we think that it is necessary to provide more devices for ultrasound osteodensitometry of the heel bone which are mobile, fast and enable examination of a larger number of patients especially in rural areas. This is the way to ensure prevention and refer the patients to further diagnostics on time, if it is necessary. This is quite indicative because of the large number of patients with osteopenia, before the menopause period.

References