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Comparison of the Bone Densitometry Results of Norland XR-36 and XR-46 Dual X Ray Absorptiometry (DXA) Scanners in the Rat Femurs

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Abstract:

Background and Objectives: It is important to obtain comparable results from different densitometry scanners in especially experimental studies. The aim of this experimental study in rat femurs is to compare bone densitometry results determined by two different DXA scanners of the same manufacturer performed at two different institutes.

Materials and Methods: Sixty female Wistar rats were the subject of this study. The rats were divided into four group and the groups were as follows: group 1 (n=15) (control), group 2 (n=15) (sham operated), group 3 (n=15) (ovariectomized) and group 4 (n=15) (ovariectomized and treated with losartan for eight weeks). Femurs of rats were collected and analyzed by Norland XR-36 and Norland XR-46 model DXA devices at different institutes by the same staff. In order to compare the two scanners results Paired samples T test, ANOVA and post hoc test was performed and $p<0.05$ considered significant.

Results: The (bone mineral concentration) BMC and (bone mineral density) BMD results of two different scanners were not significantly different according to statistical analysis ($p>0.05$) in the all 4 groups. Additionally BMD values were significantly decreased in group 3 compared to the control group ($p<0,005$). Although losartan treatment caused a significant increase in the BMD values of group 4 compared to the ovariectomy group ($p<0.005$) this increase could not reach the BMD values in the control group.

Conclusions: Although it is important to use the same scanner for follow up DXA measurements in human, this experimental rat study shows that different scanners of the same manufacturer provides comparable results.

Keywords: Dual X-ray absorptiometry, osteoporosis, rats, repeatability.

INTRODUCTION

The decision of the presence of osteoporosis and bone loss is basically depend on the bone mineral density measurements which are performed by DXA scanners. Most of the recent reports of experimental studies are performed by DXA devices [1]. Additionally the comparability of the results of different scanners is an important issue. There are three main DXA scanner brands (Lunar, Norland, Hologic) and there are some studies that have indicated interchangeability of these scanners' results and have concluded that they are comparable with cross calibration [2]. However in the previous studies performance of the analyses in the same scanner is the preferred methodology. In a previous phantom study comparability of different scanners has been documented (Hologic scanners) [3]. Additionally there are many previous studies with rats evaluating bone densitometry [4, 5]. In the literature there are few studies performing bone mineral density analysis in a study with different scanners. The aim of this study was to compare BMC and BMD results of two different DXA devices (Norland XR-36 and XR-46) of the same manufacturer in an experimental rat model. Additionally we preferred to perform the study in group of rats with simulation of different states (ovariectomy and under losartan treatment) of postmenopausal ages as they are generally subjects of densitometry. Losartan is one of the most common angiotensin 2 (AT2) blockers which are effective bone preventive agents.

MATERIALS AND METHODS

Sixty female Wistar rats (3 months old and approximately 300 g, Akdeniz University, Faculty of Medicine, Animal Laboratory) were included in this study. The experimental study and procedures were approved by Akdeniz University Animal Care and Use Committee. In order to simulate different postmenopausal states of women (who are subjects of routine DXA studies) the rats were divided into

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Table 1. Comparison table of specialties of the two scanners.

Specifications	Norland XR-36	Norland XR-46
Scan time (hip/spine)	3/2 min	<3/<2 min
Additional specialties	Compensation for wide range of tissue thickness	Acommodation of wide range of patient sizes
Additional specialties	Exclusive dynamic filtration	Large active scan area

Table 2. BMD and BMC values of four rat groups measured with two different scanners.

	BMD1(mg/cm^2) (mean±SD)	BMD2(mg/cm^2) (mean±SD)	P values	BMC1 (mg) (mean±SD)	BMC2 (mg) (mean±SD)	P values
Group 1 (control)	140±60	130±50	0,115	430±40	420±40	0,756
Group 2 (sham)	130±10	130±70	0,820	390±90	390±60	0,960
Group 3 (ovariec-tomy)	120±50	120±40	0,631	340±40	340±30	0,808
Group 4 (losartan)	120±60	120±70	0,633	360±50	360±50	0,718

BMD1 and BMC1 indicates the results of Norland XR-46 scanner and BMD2 and BMC2 Norland XR-36.
P values represent T test results.

four groups; group 1 (n=15) (control), group 2 (n=15) (sham operated), group 3 (n=15) (ovariectomized) and group 4 (n=15) (ovariectomized and treated with losartan for eight weeks). Losartan (Losartil, Drogsan Co., Ankara, Turkey) (5 mg/kg/day) was dissolved in the water and administered to the animals by oral gavages 12 weeks after the ovariectomy and repeated for 8 weeks. All animals were sacrificed after 20 weeks and whole femurs of rats were collected for BMC and BMD analysis. After removing all soft tissues around femur bones, the bones were wrapped in gauze with isotonic saline and kept at -20ºC. The bones were waited at room temperature for four hours before performing measurements. BMC and BMD measurements of all groups (including 15 femurs in each group) were performed in whole femur. The position of the femurs were uniform with anterior surface of the bone up and parallel to the longitudinal axis of the scanner table without any background material (like plastic or other uniform material) just on a sheet of absorbent paper. The analyses were performed first by a DXA device (Norland XR 46, Norland, USA) with a speed of 1mm/s and 0.5x0.5 mm resolution in small subject program with same duration for each scanner. Approximately six months later second BMD measurements of femurs were repeated by another DXA device (Norland XR 36, Norland, USA) of same manufacturer which is located at another city in the same country. The specifications of both scanners are summarized in Table **1**. Both measurement and analysis of bones were performed by the same staff. The BMC levels as mg and BMD as mg/cm^2 were obtained and both BMC and BMD results were compared by Paired Samples T test, ANOVA and post hoc test and p<0,05 was considered to be statistically significant. According to the post hoc power analysis that was performed according to the mean and SD differences of BMC values the power of the study with 0.05 tolerance was 98%.

RESULTS

In the group 1 the mean BMD and BMC values of first (Norland XR-46) (140±60 mg/cm2 and 430±40 mg) and second (Norland XR-36) (130±50 mg/cm2 and 420±40 g) scanner were not significantly different (p=0,115 and p=0,756 respectively). The difference between the mean BMD and BMC values of first (130±10 mg/cm2 and 390±90 mg) and the second (130±7 mg/cm2 and 390±60 mg) scanner was not significantly different (p=0,82 and p=0,96 respectively) in group 2 (Table **2**).

In the group 3 and group 4 mean BMD values of first (120±50 mg/cm2 and 120±60 mg/cm2 respectively) and second (120±40 mg/cm2 and 120±70 mg/cm2 respectively) scanner were not significantly different (p=0,631 and p=0,633 respectively). Also mean BMC values of group 3 and group 4 of first (340±4 mg and 360±50 mg respectively) and second scanner (340±30 mg and 360±50 mg respectively) were not significantly different (p=0,808 and p=0,718 respectively) (Table **2**).

Additionally BMD values were significantly decreased in group 3 (ovariectomy) compared to the control group (p<0,005). There was a significant increase in the BMD values of losartan group (group 4) compared to the ovariectomy group (p<0,005) however this increase could not reach the BMD values in the control group.

According to comparative analysis of BMD and BMC values by one-way ANOVA analysis and posthoc test there wasn't significant difference between results of both scanners (p<0,005).

DISCUSSION

Our results showed the difference in BMD values of the ovariectomy rat group and control and sham operated group.

Although medication with AT2 receptor blockers revealed improvement in the BMD not reaching control group BMD values in our study. Previously angiotensin dependent stimulation of bone resorption have been shown in osteoclast and osteoblast cultures and effect of bone resorption in these cultures by AT 1 and AT 2 [6]. Additionally the detrimental effect of AT 2 in ovariectomized animals has been previously demonstrated [6]. Shimizu *et al.* have achieved prevention of osteoporosis by AT1 receptor blockers: olmesartan [7]. However there were also contradictory results in the literature. Li *et al.* couldn't have shown effect of losartan on osteoporosis but they started the treatment just after ovariectomy [8]. In this study the losartan treatment was started after documentation of osteoporosis induced by ovariectomy.

According to the previous studies the DXA systems have been found to be reproducible; however considerable variability has been found between measurements of different scanners [9]. Thus, it has been usually recommended to perform follow up of patients or subjects with the same scanner previously. This study group consists of a large number of subjects of a homogeneous group and we demonstrated that same manufacturers' different scanners might give comparable results in two different institutes.

New generation DXA systems have been introduced in the field and single detector pencil beam (PB) scanners are replaced by multiple array detector fan beam (FB) scanners. Fan beam scanners are faster and give more precise results. Another study comparing four different FB and PB systems (Lunar and Hologic), has also showed that there are significant differences between different manufacturers systems [10]. A comparative study with same manufacturers QDR 4500 W (FB) and QDR 1000 W (PB) scanners has concluded that the results of these 2 scanners cannot be compared [11]. However, a rat bone study on pencil, fan and cone beam DXA scanners has showed precise and accurate BMC measurements except an overestimation of BMC with a dependence on the bone ash weight which was a less pronounced problem with cone-beam scanner compared to the pencil or fan beam scanners [12]. In a comparative study with PB, FB and cone beam system measurements, it has been demonstrated that they have sufficient precision in the estimation of rat femur [13].

A precision study with infant whole body phantomin Hologic scanners has showed importance of cross calibration in order to provide precision [2]. Additionally bone densitometry analysis by DXA devices have been performed in many studies with accuracy in rats or rat bones previously [5]. The present study also confirms the repeatability of the measurements of different devices in different institutes.

The densitometry devices in this study; Norland XR-36 (introduced at 1998) and XR-46 (introduced in 2002) are different models of the same manufacturer and XR-46 model is a one step higher generation. The technical advances of XR-46 over XR-36 are, faster scanning time especially in AP spine and femur measurements which are frequently acquired in routine practice and a larger active scan area allowing patient's scan with a wide range of sizes. The only study comparing Norland XR-36 and Norland XR-46 is a human whole body analysis has showed a tendency of XR-36 to measure more lean mass and XR-46 more fat mass [14]. This study is the only study which compares these scanners in an experimental rat model. The results of this study showed that different model DXA devices of the same manufacturer might provide comparable results.

CONCLUSION

Although human studies with DXA scanners can give conflicting results, comparative experimental studies in the field of bone densitometry conclude with more robust results and according to our study two different scanners of the same manufacturer results might be comparable. Thus, this study shows that it is possible to perform multicenter experimental studies with different DXA devices.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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Declared none.

LIST OF ABBREVIATIONS

AT 1 = angiotensin 1

AT 2 = angiotensin 2

BMC = bone mineral concentration

BMD = bone mineral density

DXA = dual X ray absorptiometry

FB = fan beam

PB = pencil beam

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