SHORT TERM EVALUATION OF CHANGES IN ELASTIC PROPERTIES OF BOVINE TRABECULAR BONE DUE TO THE STORAGE METHOD

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1. Introduction

A trabecular bone is a one of main bone component determining the strength of the entire bone [1, 2]. It is present in the epiphysis of long bones and fills the interior of short, flat and irregular bones. Even a small reduction in mass and quantity of trabeculae in the bone leads to a significant reduction of the bone strength. The studies of the trabecular bone are undertaken by many researchers analyzing the bone strength.

One of the most important aspects regarding the trabecular bone studies is a method of storing the bone samples [3-5]. Since the bone is a composite material including an organic and mineral phase, as well as a solid and liquid phase, the storage method may affect the mechanical properties of the trabecular bone in time.

The study aimed to evaluate the effects of the trabecular bone storage method on its elastic properties. The bovine trabecular bone samples stored in air at room temperature (G1 group), in formalin at room temperature (G2 group) and frozen stored (G3 group) for 21 days were subject to tests.

2. Material and Method

The samples were taken from the spongy part of the head of bovine femoral bone. All animals were at similar age and came from the same species and herd.

Slices were cut from the epiphysis of the head of the femoral bone and 90 cylindrical samples with a diameter and height of 10 mm were taken. Depending on its size, 2-3 samples were taken from each bone.

The whole bones were stored in a cold room. The first measurement made immediately after sampling (T_1 time) was used as a reference measurement. The samples were stored in the following conditions: room temperature 21°C and humidity 35% in 10% formalin solution and frozen at -20°C.

The samples were subject to compression tests on Instron E3000 testing machine to determine the elastic modulus. The test procedure was as follows:

The sample was subject to initial compression force 3 N for 10 seconds, and five compression cycles in the elastic range were carried out until 0.65% strain was recorded. Each loading-unloading cycle lasted 60 seconds with 10 second intervals between the cycles. For loop obtained from fifth cycle tangential modulus was calculated. After every cycle strain channel was reset to zero.

The control measurements for samples in each group were carried out after 7 (T_2), 14 (T_3) and 21 (T_4) days from the sampling date.

A Szapiro-Wilk test at p=0.05 value was used to determine the distribution type for sample moduli recorded for each group.

A statistical Kolmogorov-Smirnov test at p=0.05 value was used to evaluate changes in average modulus value in time for each group using "R" software.

3. Results

Table 1 shows average, minimum and maximum values and standard deviations for the compression test for each group.

	G1 group	G2 group	G3 group
Modulus T_1 [MPa]	1759 (SD ±1626)	1985 (SD ±0.1267)	1756 (SD ±1157)
Modulus T_2 [MPa]	1937 (SD ±1384)	1837 (SD ±117)	1745 (SD ±1378)
Modulus T_3 [MPa]	2500 (SD ±1218)	1714 (SD ±915)	1770(SD ±1147)
Modulus T_4 [MPa]	3015 (SD ±1174)	1785 (SD ±1173)	1872 (SD ±1289)

Tab. 1. List of average value of moduli recorded for each group.

For a group of frozen samples, the values were characterized by a normal distribution for all measurements. All measurements for a group of samples stored in formalin and dry samples were characterized by a log-normal distribution. Divergent results can be observed in some cases and up to three results divergent from the normal distribution were recorded for each group.

For a group of frozen samples and samples stored in formalin, changes in average modulus value were statistically insignificant.

For a group of dry samples (G1), an increase in average module value in time was recorded. The changes average modulus in this group were statistically significant.

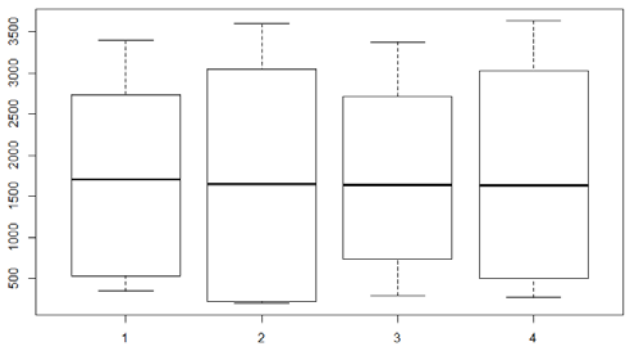

Fig. 1. Changes in time average modulus value for a group of frozen samples.

Fig. 1 show the statistical test results using box plots for frozen group. For frozen samples and samples stored in formalin, average values for subsequent measurements were similar. For dry samples, average values increased during subsequent measurements.

4. Discussion

Based on the results, freezing the samples and storing the samples in 10% formalin solution did not significantly affect changes of elastic modulus within a period of 21 days. Thus, the methods can be used to store bovine trabecular bone samples.

Storing the samples at room temperature resulted in an increase in elastic modulus, most probably due to the loss of moisture. Based on the data available in the literature, dry bones show better strength properties, i.e. higher elastic modulus and relative strength compared to the wet bone. Thus, the method should not be used to store trabecular bone samples.

A significant scatter of the recorded values compared to the average value was observed between the groups. It is due to the fact that some samples were taken from the same bone which may affect the recorded values, since the strength may vary depending on the area of the femoral bone head the sample was taken from.

References

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