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RELATIONSHIP AMONG MINERAL CONTENT AND ELASTIC MODULUS FROM ULTRASONIC TEST OF HUMAN TRABECULAR BONE

Abstract

In this paper The presents the relationship among the the mineral content of human trabecular bone and its elastic modulus measured by ultrasonic test. Examined two groups of samples - osteoporotic and coxarthrotic. Relationship between bone mineral content and elastic modulus described the correlation coefficient R. For both groups of samples obtained R-values in the range 0.71 ÷ 0.72 for osteoporotic samples and 0.70 ÷ 0.7 2 for coxarthrotic samples. R-values obtained for both groups of samples are similar and suggest that the content of the mineral phase of bone is a good indicator for the indirect estimation of elastic properties of bone measured by elastic modulus.

INTRODUCTION

The mineral content of trabecular bone changes with age. About 20-30 years of age is maximal, next appear a gradual process of trabecular loss and a decrease elastic properties and bone strength.

The elastic properties of human trabecular bone can be estimated with using different methods eg. mechanical test, calculated finite element method *FEM* or ultrasonic test [2], [3].

The aim of the study is to determine relationship among mineral content and elastic modulus from ultrasonic test of human trabecular bone.

2. MATERIAL AND METHOD

Investigated material were 42 samples of human trabecular bone collected from osteoporotic and coxarthrotic femoral heads gained in result of hip arthroplasty. The samples have diameter 10 mm and 8,5 mm height. Manner of collecting sample was described in [1].

In the study estimated mineral content of bone used ash density. In this aim samples were burning in temperature 500 ^{o}C by 15 hours [4]. After burning in sample remains only mineral phase because organic phase was destroyed due to the effect of temperature.

Ash density *Ash.D* was calculated by divide mass burned sample by its volume before burning.

Ultrasonic test was carried out using ultrasonic generator *Panametric 5058 RP* with using *Digital Scan Osciloskope – DSO* software.

The frequency ultrasonic transducers were 0,5 and 2 Mhz. Before the measurement the samples were inserted in the vacuum pump, where removed air from the pores. Next the pump is flooded with water in the aim filling by water volume of pores. Measured wave velocity and on the base elastic modulus *E* was calculated.

3. RESULTS

In Tabs. 1-2 presented obtained values of ash density *Ash.D*, elastic modules $E_{0,5}$ – for frequency 0,5 MHz and E_2 – for frequency 2 MHz for both groups of samples.

In Figs. 1-4 presented relationships among ash density, elastic modules $E_{0,5}$ and E_2 for both groups of samples.

Tab. 1. Values of ash density *Ash.D*, elastic modules $E_{0,5}$ and E_2 for osteoporotic samples

	min	**max**	**mean**	**SD**	**RSD**
Ash.D, g/cm^3	0,113	0,592	0,251	0,097	39 %
E $_{0,5}$, MPa	2533,3	6442,9	4415,5	1171,4	26 %
E $_2$, MPa	1706,8	8040,5	5384,5	1462,3	27 %
SD - standard deviation RSD - relative standard deviation					

Tab. 2. Values of ash density *Ash.D*, elastic modules $E_{0,5}$ and E_2 for coxarthrotic samples

	min	**max**	**mean**	**SD**	**RSD**
Ash.D, g/cm^3	0,174	0,513	0,341	0,089	26 %
E $_{0,5}$, MPa	1612,5	7069,9	4957,3	1401,3	28 %
E $_2$, MPa	1938,2	9472,5	6704,5	2047,5	31 %
SD - standard deviation RSD - relative standard deviation					

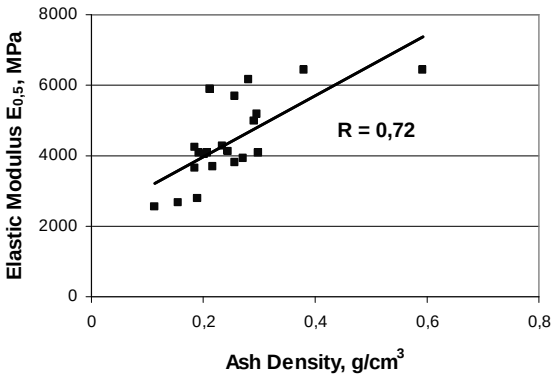

Fig. 1. The graph dependence between *Ash.D* and Elastic modulus $E_{0,5}$ for osteoporotic samples

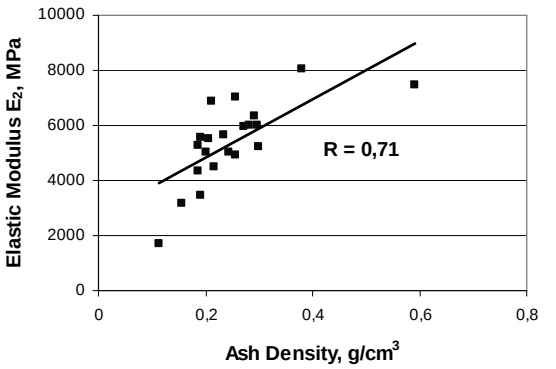

Fig. 2. The graph dependence between *Ash.D* and Elastic modulus E_2 for osteoporotic samples

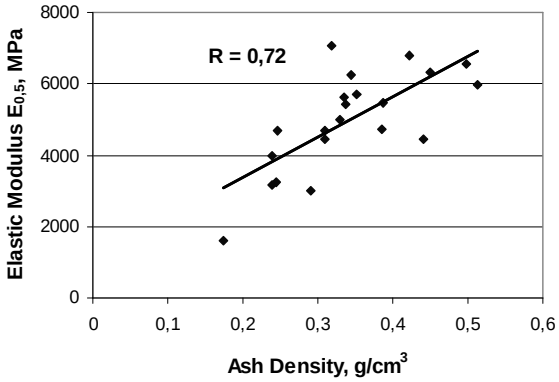

Fig. 3. The graph dependence between *Ash.D* and Elastic modulus $E_{0,5}$ for coxarthrotic samples

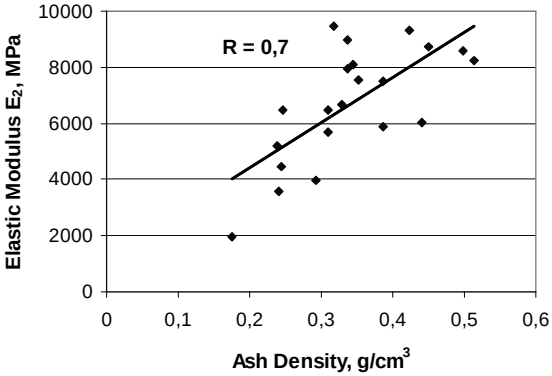

Fig. 4. The graph dependence between *Ash.D* and Elastic modulus E_2 for coxarthrotic samples

SUMMARY

From investigation obtained significant relations among ash density and elastic modulus from ultrasonic test.

The values coefficient of correlation are similar for both investigated groups of samples and both frequencies of ultrasonic transducers, its value is about $R = 0,7$.

The mean value of elastic modules for frequency 2 MHz are higher in comparison to 0,5 MHz, for osteoporotic group about 22% and for coxarthrotic group about 35%. It is pointed on influence frequency used transducers on obtained values of modules, however it have no influence on the power of relationships between ash density and modulus.

Obtained values for both groups of samples are similar and suggest that the content of the mineral phase of bone is a good indicator for the indirect estimation of elastic properties of bone measured by elastic modulus.

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ZALEŻNOŚĆ POMIĘDZY ZAWARTOŚCIĄ FAZY MINERALNEJ LUDZKIEJ KOŚCI BELECZKOWEJ A JEJ MODUŁEM SPRĘŻYSTOŚCI POMIERZONYM METODĄ ULTRASONOGRAFICZNĄ

Streszczenie

W pracy przedstawiono zależności pomiędzy zawartością fazy mineralnej ludzkiej kości beleczkowej a jej modułem sprężystości pomierzonym metodą ultrasonograficzną. Badaniu poddano dwie grupy kości – osteoporotycznych i koksartrycznych. Siłę zależności pomiędzy zawartością minerałów w kości a modułem sprężystości opisano współczynnikiem korelacji R. Dla badanych grup próbek uzyskano wartości współczynnika R w zakresie 0,71÷0,72 dla próbek osteoprotycznych oraz 0,70÷0,72 dla próbek koksartrycznych. Wartości współczynnika R otrzymane dla obu grup próbek są podobne i wskazują na to że zawartość fazy mineralnej w kościach jest dobrym wskaźnikiem do pośredniej oceny własności sprężystych kości mierzonej modułem sprężystości.

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