# Mechanical Strength of Bone Graft Prepared From Biomimetic Corals

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## INTRODUCTION

- In the last decades, bone grafting substitutes have become a daily orthopedic and dental procedure.
- Because of its structural similarity to trabecular bone, coral mineral is used as a bone substitute.
- Sea derived coral bone grafts are biocompatible, osteoconductive, and strong scaffolds which can carry growth factors and stem cells.
- Along with the increase in pollution of the corals growth environment -the oceans- the need to develop technologies for corals growth in a controlled environment is increasing.
- Aquariums are offering optimal conditions in which corals growth and mineralization occurs up to 10 times faster and possibility to enrich coral mineral with bioactive properties.
- It was found that corals grown in the aquarium are chemically and structurally identical to corals originated in the sea.
- One of the required mechanical properties of bone is compressive strength. Therefore, it is important to check whether mechanical properties of corals that grew up in the aquarium are similar to those originated in the sea, especially compressive strength properties.

## OBJECTIVES

- The aims of this study was to compare the mechanical properties of corals that grew up in the aquarium to corals from the sea and to shelf product corals.

## METHODS

4x4x4[mm] cubes were prepared from aquarium origin corals (CoreBone, Israel), sea origin corals and shelf product corals (Biocoral, Inoteb, Gonnery, France). (Fig. 1)

Conducting compressive test using a loading machine (Instron) (Fig. 2)

Obtaining Stress-Strain curves for each sample. Analysis of mechanical properties: modulus of elasticity, ultimate compressive strength and toughness (fracture energy) (Fig. 3)

Performing statistical tests for the results (Tables 1,2, Fig. 4)

*Fig. 1: A sample of the prepared cubes.*

*Fig. 2: Crushed sample after compressive test using an Instron machine.*

## RESULTS

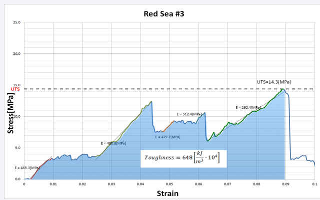


*Fig. 3a: Stress-Strain curve for Red Sea coral*

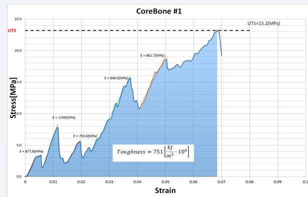


*Fig. 3b: Stress-Strain curve for coral grew up in the aquarium of CoreBone.*

*Table 1: Results for the 3 samples groups. N-number of samples, UTS – ultimate compressive strength [MPa], Young's modulus [MPa], Toughness* $\left[\frac{kJ}{m^3}\cdot 10^4\right]$

| | Group | N | Max. | Min. | Average | STD | ANOVA P-value |
|---|---|---|---|---|---|---|---|
| UTS | Red Sea | 5 | 30.7 | 9.1 | 17.0 | 8.1 | 0.000006 |
| | Biocoral | 15 | 10.6 | 3.3 | 7.8 | 1.9 | |
| | CoreBone | 33 | 34.8 | 7.9 | 17.0 | 6.1 | |
| Young's Modulus | Red Sea | 5 | 1215 | 436 | 767 | 338 | 0.008 |
| | Biocoral | 15 | 1664 | 208 | 930 | 397 | |
| | CoreBone | 33 | 1620 | 68 | 574 | 337 | |
| Toughness | Red Sea | 5 | 804 | 76 | 529 | 282 | 0.00008 |
| | Biocoral | 15 | 169 | 21 | 50 | 45 | |
| | CoreBone | 33 | 1974 | 104 | 499 | 374 | |

*Table 2: Bonferroni correction tests results. RSC – Red Sea corals, BCC – Biocoral corals, CBC – CoreBone corals.*

| | Groups | bonferroni α≤0.016667 |
|---|---|---|
| UTS | RSC-BCC | 0.00049 |
| | RSC-CBC | 0.97749 |
| | CBC-BCC | 0.000001 |
| Young's Modulus | RSC-BCC | 0.42359 |
| | RSC-CBC | 0.24060 |
| | CBC-BCC | 0.00245 |
| Toughness | RSC-BCC | 0.000003 |
| | RSC-CBC | 0.86518 |
| | CBC-BCC | 0.00003 |

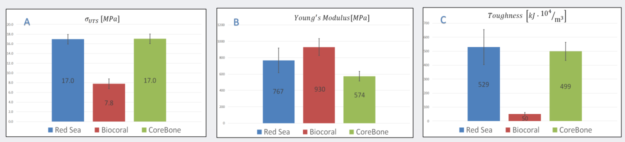


*Fig. 4: Mean values of all parameters: A – UTS, B – Young's Modulus, C – Toughness.*

- We can notice that the curves above are characterized by the shape of sawtooth. The sawtooth appearance of the stress-strain curves indicates a porous compartmental mineral structure and was found in additional experiments done in the past on corals. Each small peak represent the onset of a crack. The sharp reduction in stress following each peak results from the release of stored strain energy due to the formation of the crack. Stress then continues to build up until another crack occurs, and eventually after several cracks develop, the sample fractures completely.
- Despite the rapid growth of corals that grew up in the aquarium they retain their mechanical properties.
- UTS - Based on the Bonferroni correction results we can conclude that there is no statistical difference between sea derived corals and corals that grew up in the aquarium.
- Young's modulus - Based on the Bonferroni correction results we can conclude that there is no statistical difference between sea derived corals, corals that grew up in the aquarium and Biocoral corals.
- Toughness (fracture energy) - Based on the Bonferroni correction results we can conclude that there is no statistical difference between sea derived corals and corals that grew up in the aquarium.

## CONCLUSIONS

- **The results show that corals that were grown in aquarium are similar in their compressive properties to corals originated from the sea. Hence, we can conclude that there is a great potential and promise in producing a bone substitute from aquarium source, which will replace and will serve as an alternative to bone substitute of corals from the sea source currently used in the industry.**