Nanoindentation of Hydrated Mineralized Tissues – Effect of Fluid on Mechanical Properties.

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Statement of Purpose: Nanoindentation as a technique is moving away from traditional materials and more towards biological materials. To ensure more realistic data, testing in fluid is becoming more commonplace to attempt to mimic in vitro conditions. The fluids used however have not been standardized and different studies have used different fluid media based on accessibility and sometime cost. In preliminary studies it has been seen that some fluids can actually degrade the mechanical properties of the material through demineralization of the specimen which can cause deviations in the results obtained. This investigation takes common fluids used to rehydrate mineralized tissues such as teeth and bones and studies the effect on the mechanical properties of the samples as a function of storage time.

Methods: Human premolar tooth samples and mouse femur samples were sectioned and polished in preparation for nanoindentation testing. The quasi-static and dynamic mechanical properties were obtained initially and after storage in different fluid media for up to 7 days. Fluid media included deionized water, PBS solution, HBS solution and HAP solution. Nanoindentation testing was carried out on the same samples before hydration, and then once per day for the full 7 days to see if there was any correlation between time stored and mechanical property degradation. Care was taken to ensure testing on each sample occurred at a similar location to the previous indent position to minimize deviation in the results.

Results/Discussion: Storage in all fluid media had an effect on the mechanical properties of both the teeth and bone samples. In each of the fully hydrated samples there was a reduction in the hardness and modulus compared to their partially hydrated state. Although the mechanical properties degraded over time for all samples, those stored in the de-ionized water showed the greatest reduction of properties which is concerning as this is the most common fluid used currently.
To date there is no controlled method for testing mineralized tissues using nanoindentation in fluid, and hence published results in this field vary greatly due to testing conditions. This study will bring awareness to the community on the effects that different fluid media have on the mechanical properties of biological samples in order aid in bringing uniformity to similar studies.

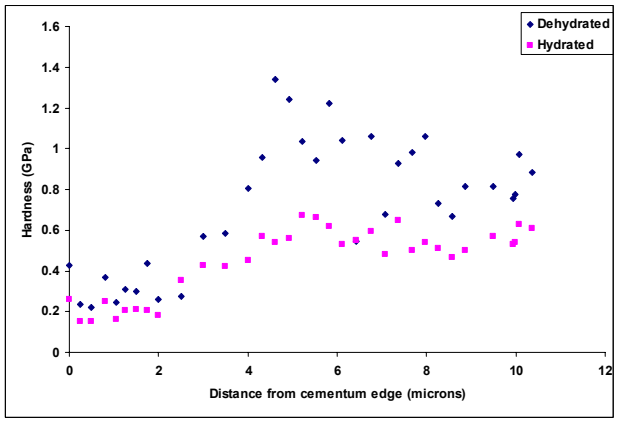

Figure 1. Plot of Hardness vs position in sample across cementum-dentin junction showing reduction in mechancial properties for partially hydrated and fully hydrated sample.

Conclusions: Testing of both bone and teeth resulted in a degradation of both hardness and modulus after immersion in fluid media. The viso-elastic components were also different before and after immersion. De-ionized water was shown to have the most detrimental effects on the mechanical properties suggesting a demineralization process is occurring while storing the sample.