# TAILORED MECHANICAL PROPERTIES OF POLYVINYL ALCOHOL HYDROGELS FOR ARTICULAR CARTILAGE REPAIR

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## Introduction

Articular cartilage (AC) defects are one of the most common symptoms of osteoarthritis, a degenerative disease affecting millions of people worldwide. Synthetic hydrogels, due to their high-water content and low friction coefficient, can mimic AC structural and mechanical properties and are therefore considered promising candidates for AC repair. In particular, Polyvinyl Alcohol (PVA) hydrogels have been investigated for the repair of chondral defects, due to their hydrophilic nature, good biocompatibility and suitable mechanical strength [1,2]. However, their tribological and compressive mechanical properties are not yet optimal for the substitution of AC and are still limiting their clinical application. This work is aimed at developing improved PVA hydrogels with tailored mechanical properties that mimic the ones of the articular cartilage of human knee.

## Methods

Several scaffolds based on PVA hydrogels were prepared in different conditions, either varying hydrogel concentration (15%, 20%), either carrying out a partial oxidation treatment, or covering PVA with a superficial layer of decellularized human AC matrix. Details on the preparation of native and partially oxidized PVA hydrogels and composite PVA/AC scaffolds (Figure 1) characterized in this work can be found in previous publications [3,4]. Mechanical tests are carried out to compare the tribological and compressive mechanical properties with those of human AC. Indentation and consolidation test are developed according to a method recently proposed [5], while friction tests are carried out with a custom-made setup, based on a pin able to slide horizontally in contact with two flat surfaces, while a vertical compressive load is applied. Both the pin and the surfaces can be samples of PVA or AC, to evaluate the friction coefficient for different couplings. The applied load can be varied to simulate physiological joint compressive stress in the range of 0.5–5 MPa.

## Results

The results of indentation tests (Figure 2) show that the almost-instantaneous compressive behavior of PVA varies with the hydrogel concentration. At maximum penetration depth, a lower concentration corresponds to an inferior indentation load. Moreover, partial oxidation treatment can affect the compressive mechanical behavior, reducing PVA stiffness. Therefore, it is possible to tune the compressive elastic modulus of PVA hydrogel scaffolds to match the one of AC.

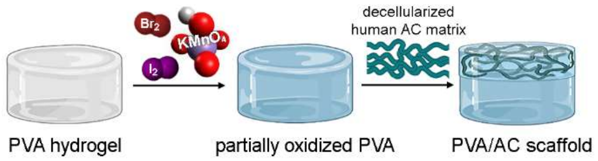


*Figure 1: Schematic representation of the preparation of native and partially oxidized PVA hydrogels and composite PVA/AC scaffolds.*

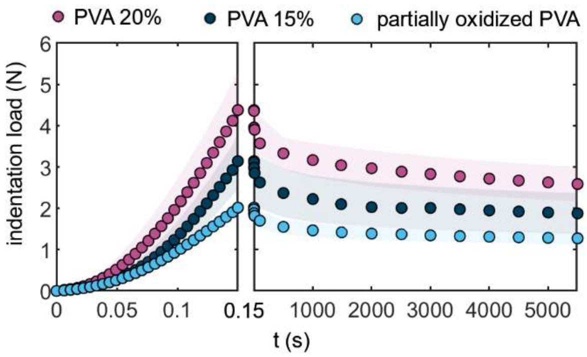


*Figure 2: Results of indentation and consolidation tests (mean with confidence interval) of native (15% and 20% concentration) and partially oxidized PVA.*

## Discussion

The compressive behavior of composite scaffold is expected to mostly depend on PVA hydrogel, due to its considerably higher stiffness, while the tribological properties can be affected by the surface coverage with decellularized human AC matrix. Moreover, the modification with AC layer will lead to the fabrication of a biohybrid scaffold which can benefit from the mechanical features of the hydrogel and the bioactive properties of the biological coating.

The mechanical properties of PVA scaffolds will be compared with the ones of AC form cadaveric donors. In further developments of this study, the functional response of PVA hydrogel scaffolds *in vivo*, namely the interaction with the tissues of the knee joint, will be evaluated by numerical analyses considering different loading conditions, exploiting a finite element model of the knee joint in healthy or pathologic conditions.

## References

1. Wei W. et al., Bioact Mater, 6: 998–1011, 2021.
2. Barbon S. et al., Processes, 9: 730, 2021.
3. Barbon S. et al., Int J Mol Sci, 21:801, 2022.
4. Stocco E. et al., Biomed Res Int, 2014:1–12, 2014.
5. Todros S. et al., Bioengineering, 9: 789, 2022.