Articular cartilage (AC) is a type of hyaline covering material for the articulating ends of bones of synovial joints which transmits high loads and maintains contact stresses at an acceptably low level. There have been numerous studies focusing on the assessment of the AC degeneration. The measures which have been utilized to evaluate the level of AC degeneration include morphology, wear particles, chemical composition in the lubricating fluid, AC thickness, surface roughness, coefficient of friction, compressive deformation, ultrasound attenuation and swelling effect. Controversies about the relationship between these parameters and the degeneration of AC still exist. Refractive index (RI) characterizes the manner of light interaction with materials during its propagation. With respect to AC, the variations of chondrocytes and different compositions of extracellular matrix would result in different scattering and absorption properties which would further affect the distribution characteristics of the AC and be measurable using the RI. To monitor the RI variation of AC could be a potential way to assess the level of cartilage degeneration. Besides, The accurate measurement of RI can be used to calibrate the artifacts in optical imaging of AC.

The current study utilized a standard confocal microscope to investigate the RI of AC harvested from fresh femoral condyles of lambs. This work is based on the previous work of Dirckx[1], but an alternative point spread function (PSF) model[2] was selected and the authors developed a sub-pixel edge detection based method to measure the optical thickness of AC slices in confocal images. The AC plugs were cut into thin slices (about 50μm) using freezing microtomy. Immersion oil with known RI was positioned next to a thin slice of AC and the two specimens were covered by a coverslip to ensure they had identical physical thickness. Due to the RI mismatch during confocal scanning, the optical thicknesses of these two specimens would be different. A sub-pixel edge detection method based on Tabatabai's one-dimensional moment edge operator was developed to accurately detect the upper and lower surfaces of the confocal slices. With these precise slice surfaces, the optical thickness could be determined. A simplified PSF of the confocal microscope was modelled to establish the relationship between the RI mismatch and the corresponding focal shift. As the focal shift could be expressed by the optical thickness ratio of the above mounting of specimens, the corresponding RI of AC was mapped through the theoretical relationship that had been established.

The developed method was shown to have a very high precision, verified by a distilled water experiment with a minimal error of 0.0045% from the authoritative measure. The overall RI of the AC used in this experiment was 1.3947 ± 0.0117 at 561nm.