The interface between nacre and bone after implantation in the sheep: a nanotomographic and Raman study

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Orthopedic bone devices can be prepared from the shells of giant pearl oysters. Nacre is biocompatible and composed of calcium carbonate (aragonite). Direct welding of bone onto the biomaterial surface has been reported but poorly investigated. Nacre from Pinctada maxima was used to prepare plates, screws and rods. Five sheep were implanted in the first metatarsus under general anesthesia and killed 2 months later. Bones were harvested and fixed in formalin. Analysis was performed by nanotomography and histology after embedding in poly(methyl methacrylate). Polished sections were imaged by scanning electron microscopy then analyzed on a Raman microscope. Nanotomography and histology evidenced the newly apposed bone composed of thin trabeculae with a lower mineralization than mature bone. Erosion of the nacre was also easily observed. The bone/nacre interface presented a characteristic toothed-comb appearance. Raman spectroscopy identified the typical bands of aragonite (1091 and 711 cm$^{-1}$) in the devices. At a distance from the interface, the bone matrix presented the typical bands of hydroxyapatite at 960, 1044 and 594–610 cm$^{-1}$ with the amide bands of collagen at 1250 cm$^{-1}$. At the bone/nacre interface, a phosphate-rich layer was observed without proteins. The newly formed bone units exhibited a band at 1075 cm$^{-1}$ corresponding to a high amount of B-carbonate substitution. The carbonate/phosphate ratio decreased between new and mature bone, and crystallinity was improved. Raman spectroscopy confirmed the modifications of the bone matrix around the nacre implant and the direct apposition of bone without an interposing organic layer between the calcium carbonate (nacre) and the calcium phosphate (hydroxyapatite).

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