Fragmenting densely mineralised acellular protrusions from articular calcified cartilage: a role in osteoarthritis?

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Objectives

High density mineralised protrusions (HDMP) from the tidemark mineralising front into hyaline articular cartilage (HAC) were first discovered in Thoroughbred racehorse fetlock joints and later in Icelandic horse hock joints. If these fragment, they could make a significant contribution to joint destruction in osteoarthritis. We looked for them in human material.

Methods

Whole femoral heads removed at operation for joint replacement or from dissection room cadavers were studied by MRI DESS at 0.23mm resolution and 26 micron resolution high contrast x-ray microtomography (XMT), then sectioned and embedded in PMMA, and block faces polished and the blocks re-imaged with 6 micron resolution XMT. Tissue mineralisation density was imaged qualitatively by backscattered electron SEM (BSE SEM) at 20kV using uncoated samples at 50Pa chamber pressure to achieve charge neutralisation. HAC histology was studied by BSE SEM after staining block faces with ammonium triiodide solution. Block surfaces were sequentially repolished and restained.

Results

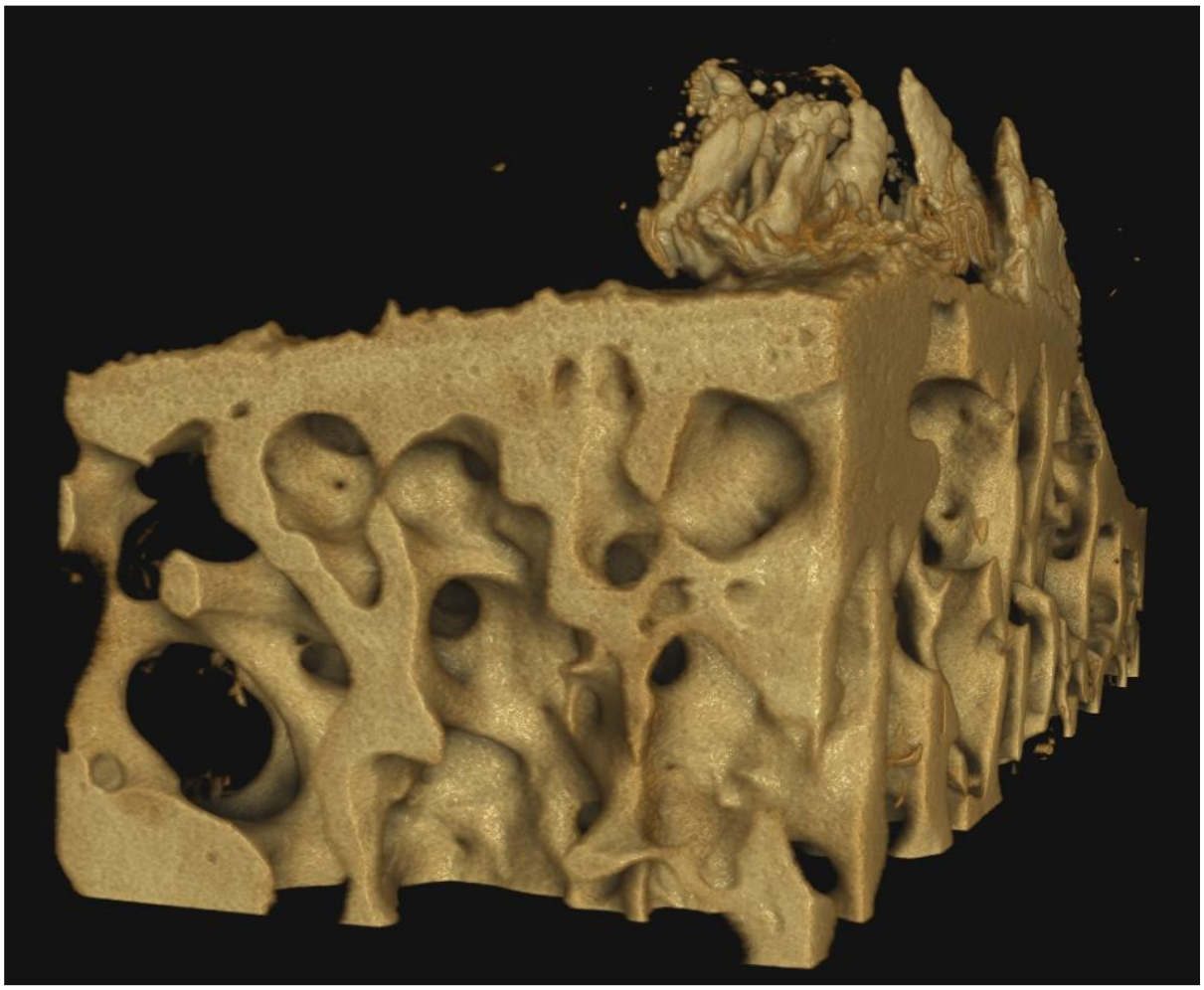

Figure: 3D rendering of 6 micron voxel resolution XMT data set showing HDMP complex projecting above subchondral bone plate. Human femoral head removed at arthroplasty.

We found examples of HDMP in HAC in human hips. Their 3D shapes are complex and may show cutting blade forms. Their mineral content (a) exceeds that of articular calcified cartilage (ACC), otherwise the densest tissue in the joint and (b) is not uniform. The mineral phase morphology frequently shows the agglomeration of many fine particles into larger concretions. Cracks within them are frequent. Dense fragments may be found within damaged HAC.

Conclusions

HDMP arise via the extrusion of an uncharacterised matrix into clefts in HAC. Little evidence of their existence remains after tissue has been decalcified with usual histological protocols. Their formation may be an extension of a normal but poorly recognised crack self-healing mechanism found in bone and ACC. They are surrounded by HAC, are dense and brittle and show innumerable fault lines within them. We provide evidence that they break *in vivo* by being able to find matching fragments in HAC. We conclude that these hard and sharp particles contribute to the shredding destruction of HAC. The osteoarthritis research community should be aware of their existence so that the frequency and possible clinical significance can be assessed in the future. Larger HDMP can be detected with the best MRI imaging.