Earliest Evidence of Proto-Dental Treatment in the Late Upper Paleolithic

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Introduction Prehistoric dental treatments are known from the Neolithic - 9,000-7,500 years before present (BP) -, when the adoption of early farming culture caused an increase of carious lesions. The few documented early cases were characterized by *in vivo* perforation of the crown surface made by a drilling tool. Here we document the earliest evidence of proto-dental therapeutic intervention on a Late Upper Paleolithic modern human lower right third molar (RM_3) from a burial in Northern Italy [1-4].

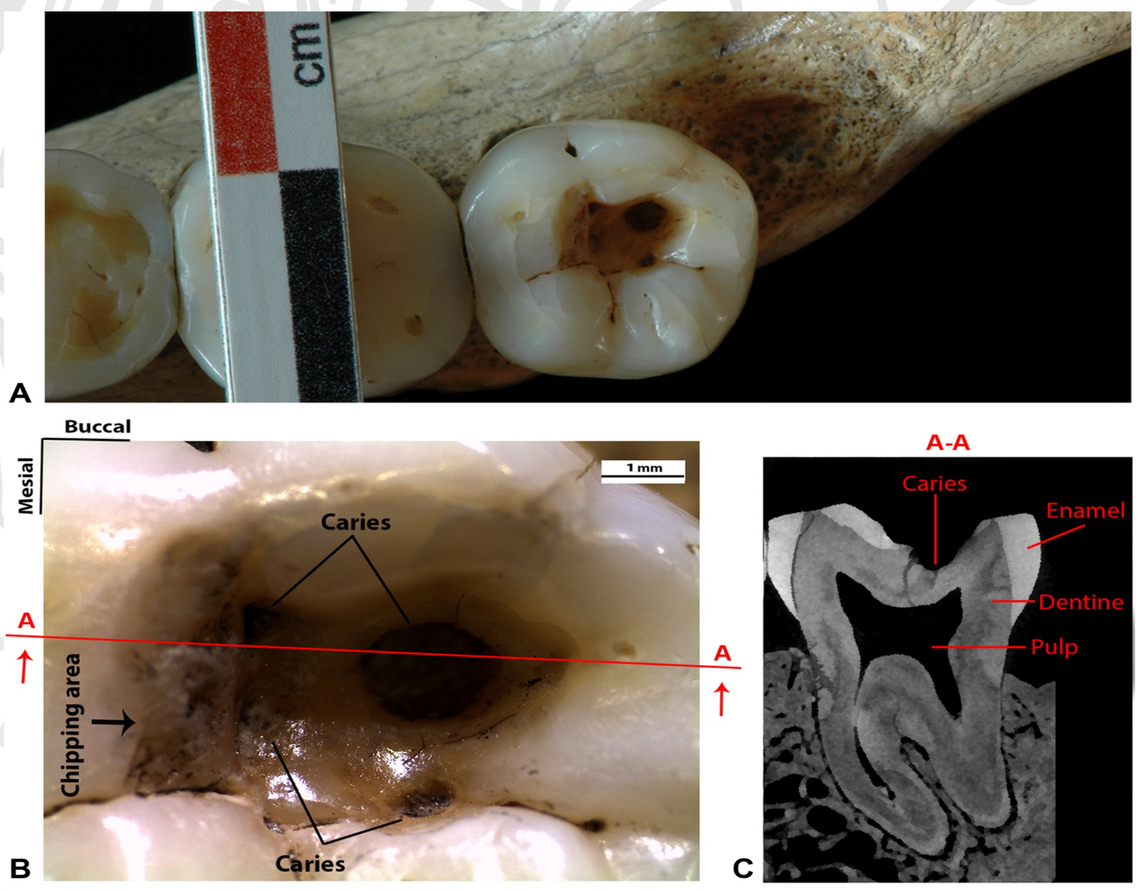

Figure 1. The lower right third molar (RM_3) of the Late Upper Palaeolithic specimen known as Villabruna. Occlusal view of the RM_3. (**B**) Detailed view of the large occlusal cavity with the four carious lesions and the chipping area on the mesial wall. Section A-A is directed mesio-distally, passing through the larger carious lesion. (**C**) MicroCT slice of the Villabruna RM_3 in correspondence with action A-A.

Materials And Methods The RM_3 belongs to a young male individual (ca. 25 years old) found in Riparo Villabruna (Sovramonte—Belluno, Italy), directly dated to around 14,160–13,820 cal yr BP. The tooth, which shows a large cavity on the occlusal surface (Fig. 1), and its antagonist were micro-CT scanned to produce 3D digital models and studied by occlusal fingerprint analysis (OFA) to evaluate the physiological occlusal movements. Scanning Electron Microscopy (SEM) cross-sectional geometry was used to visualize and analyse the striations within the cavity. Finally, experimental tests were carried out to assess the instrument used to produce the striations.

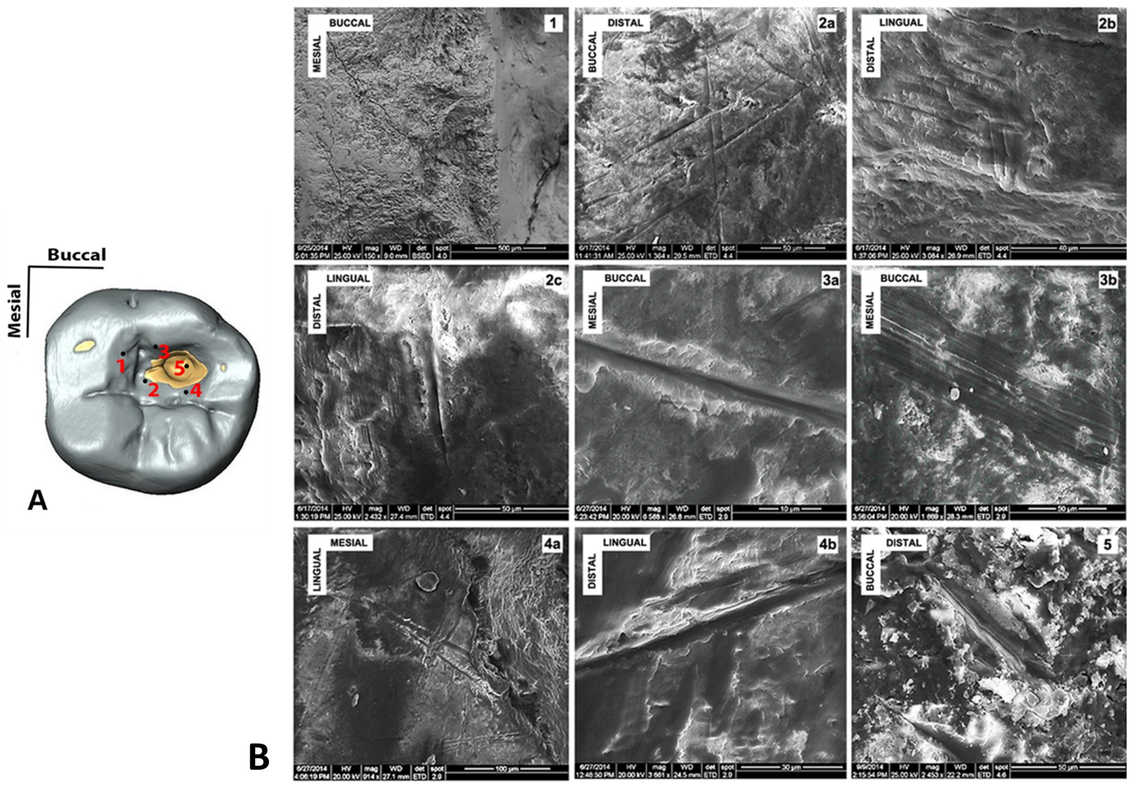

Figure 2. Scanning Electron Microscopy (SEM) images of the striations observed within the carious cavity of the Villabruna lower RM3. (**A**) Occlusal view of the RM_3 digital model, with numbers indicating some of the areas where striations were observed. (**B**) The SEM images: 1, the chipping area; 2a-b-c, the mesial area; 3a-b, the buccal wall of the cavity; 4a-b, the lingual wall of the cavity; 5, inside the large carious lesion.

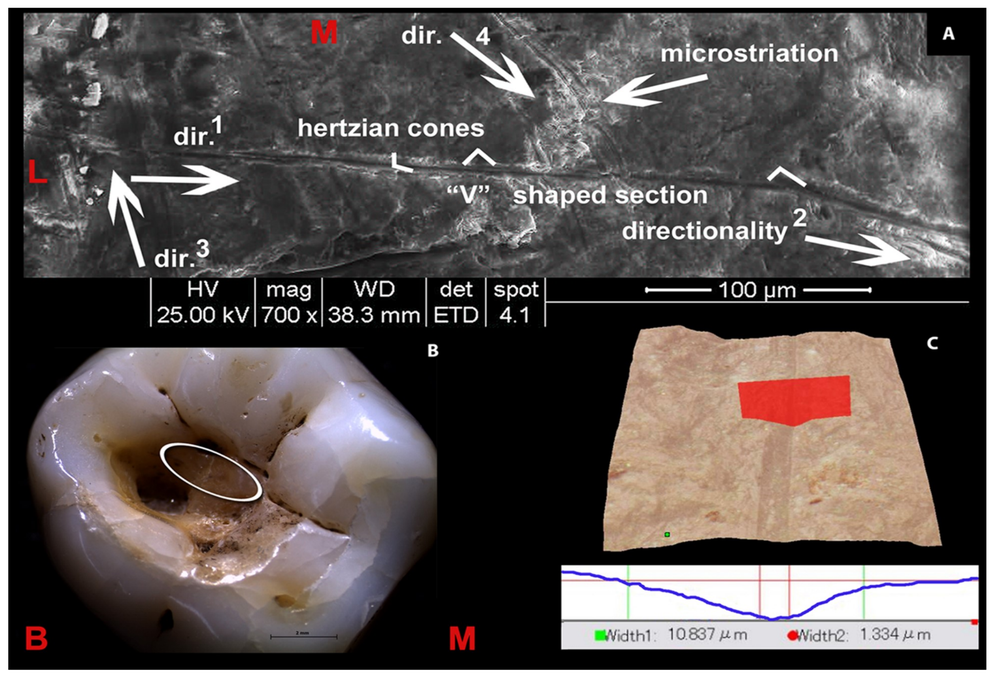

Figure 3. Morphological description of the striations observed in the Villabruna lower RM3. (**A**) SEM images with morphological and directionality striation features (the numbers indicate the sequence of the gestures). (**B**) Stereo microscopic image of the cavity and of the region (ellipse) containing the striations described in this figure (areas 2 and 4 in Fig. 2). (**C**) Example of 3D rendering and cross-section of the striation observed in the Villabruna tooth cavity (area 2 in Fig. 2). B: buccal; L: lingual; M: mesial.

Results This tooth presents a large occlusal cavity, with a polished internal surface and extensive enamel chipping traces on the steep mesial wall. The striations observed by SEM (Fig.2) have a "V" shaped transverse section (Fig. 3), as typically displayed by cutmarks on teeth [5]. Based on *in vitro* experimental replication and a complete functional reconstruction (Fig. 4), we confirm that the identified striations and the associated extensive enamel chipping on the mesial wall of the cavity were produced ante-mortem by pointed flint tools during scratching and chiseling activities.

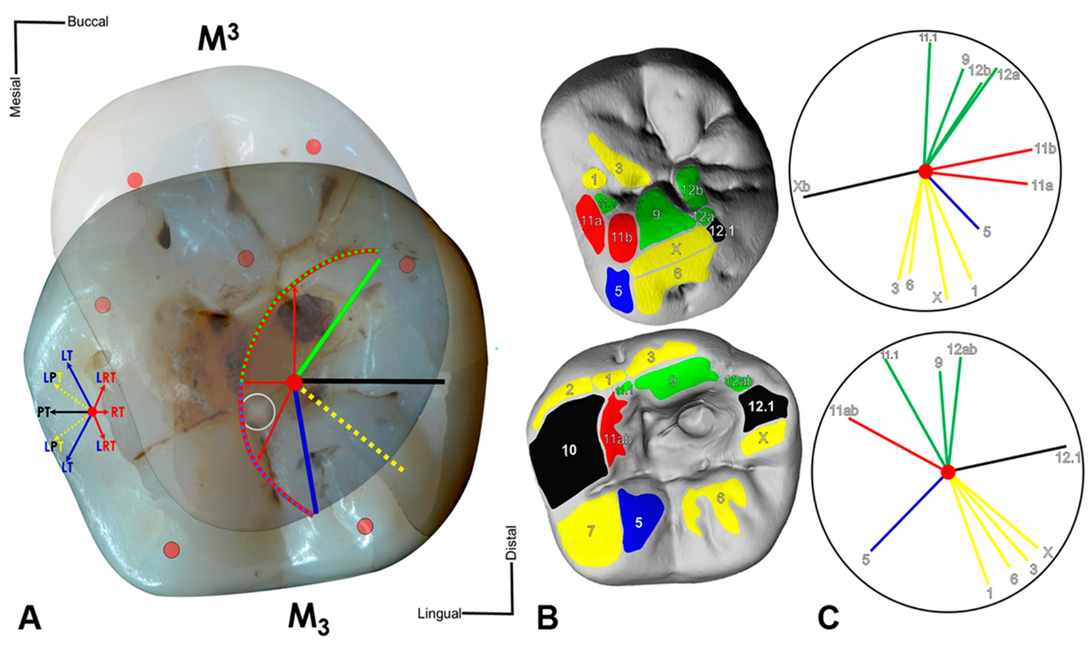

Figure 4. Occlusal relationship between the upper and lower RM3. (A) Maximum intercuspation between antagonistic crowns. M_3 transparent and mirrored for occlusal view on M_3. Red point, cusp tips; grey circle, central fossa center M_3. The dental occlusal compass (left) designates general directions of movements in mandibular symphysis out of maximum intercuspation. The dental occlusal compass (right) indicates directions of the M_3 protocone tip (red center point). Protrusion (black); lateroprotrusion (yellow); laterotrusion (blue); retrusions (red); mediotrusion (green). (B) Wear facet pattern labeled and color-coded. (C) Individual occlusal compass results showing spatial orientation of each wear facet.

Conclusion The Villabruna specimen is therefore the oldest known evidence of dental caries intervention. This study also suggests that primitive forms of carious treatment in human evolution entail an adaptation of the well-known toothpickings technique, which emphasizes levering and scratching, rather than more advanced drilling practices.

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