Enamel thickness topography and molar wear pattern in European early agriculturalists

Mona Le Luyer*, Stéphane Rottier*, Priscilla Bayle*
*PACEA, UMR 5199, Université de Bordeaux, France
mona.le-luyer@u-bordeaux.fr

Paleoanthropology Society
23rd annual meeting
Calgary, Canada
April 2014

Enamel thickness (ET) has been linked to functional aspects of masticatory biomechanics[1,2] and has been demonstrated to be an evolutionary plastic trait, selectively responsive to dietary changes[3], wear and tooth fracture[4]. European Late Paleolithic and Mesolithic hunter-gatherers mainly show a flat wear pattern, while oblique molar wear has been reported as characteristic of early Neolithic agriculturalists[5]. This study focuses on relationships between molar wear patterns and enamel thickness topographic distributions in a French Neolithic sample of early agriculturalists. As a comparative population that has experienced other masticatory and/or dietary conditions, we used a French Medieval sample.

MATERIALS and METHODS

Occlusal wear patterns were scored following Molnar (1971)[6] in second upper permanent molars (UM2) of 64 Neolithic and 311 Medieval immature and adult individuals. Using a microtomographic-based record, we virtually assess ET topography in sub-samples of UM2s from 17 Neolithic and 25 Medieval individuals. Final volumes were reconstructed with an isotropic voxel size ranging from 17.93 µm to 36.18 µm. After threshold-based segmentation, crowns were digitally isolated from roots and virtual cross-sections through the dentine horn tips of the mesial cusps of the mesial cusps were realized[7,8]. Eight variables describing ET were assessed[7-9]. 3D maps of ET distribution were created and topographic variation of standardized ET was measured in buccal and lingual aspects of virtual cross-sections[10].

RESULTS

Major differences in wear patterns are observed between Neolithic and Medieval populations (Figures 1 and 2). The Medieval UM2s show 57.23% of occlusal wear greater than or equal to stage 3, compared with 46.88% of the Neolithic sample (chi-squared=137.047, df=8, p<0.000).

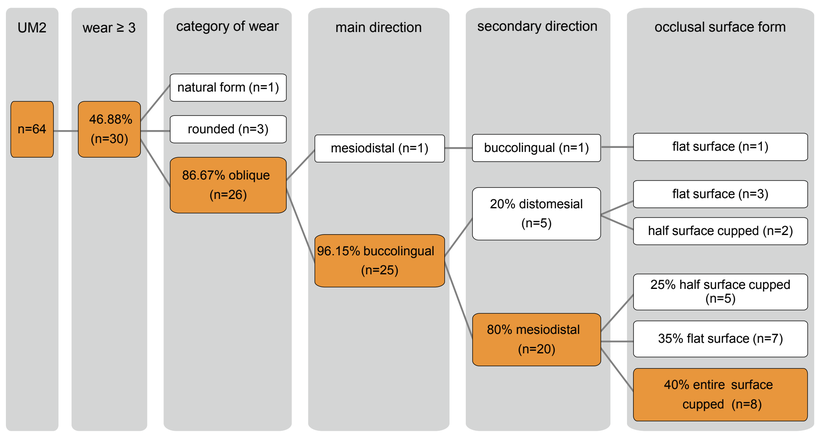

Figure 1. Patterns of occlusal wear[6] for Neolithic UM2s. Direction is indicated from the minor to the major point affected by occlusal wear. Dominant category of wear, direction and form are in orange.

In the Neolithic sample (Figure 1), oblique molar wear is largely dominant (87%). The buccolingual direction represents 96.15% of these obliquely worn UM2s. Thus, maximal loss of enamel is localized in the distolingual side of the Neolithic crown. On the other hand, Medieval UM2s show greater variation of wear patterns and only 42% show oblique wear (Figure 2).

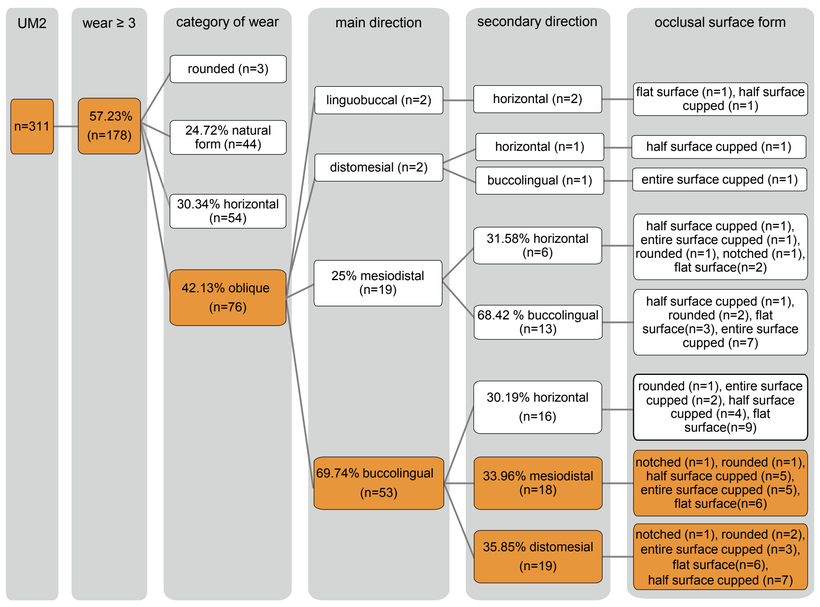

Figure 2. Patterns of occlusal wear[6] for Medieval UM2s. Direction is indicated from the minor to the major point affected by occlusal wear. Dominant category of wear, direction and form are in orange.

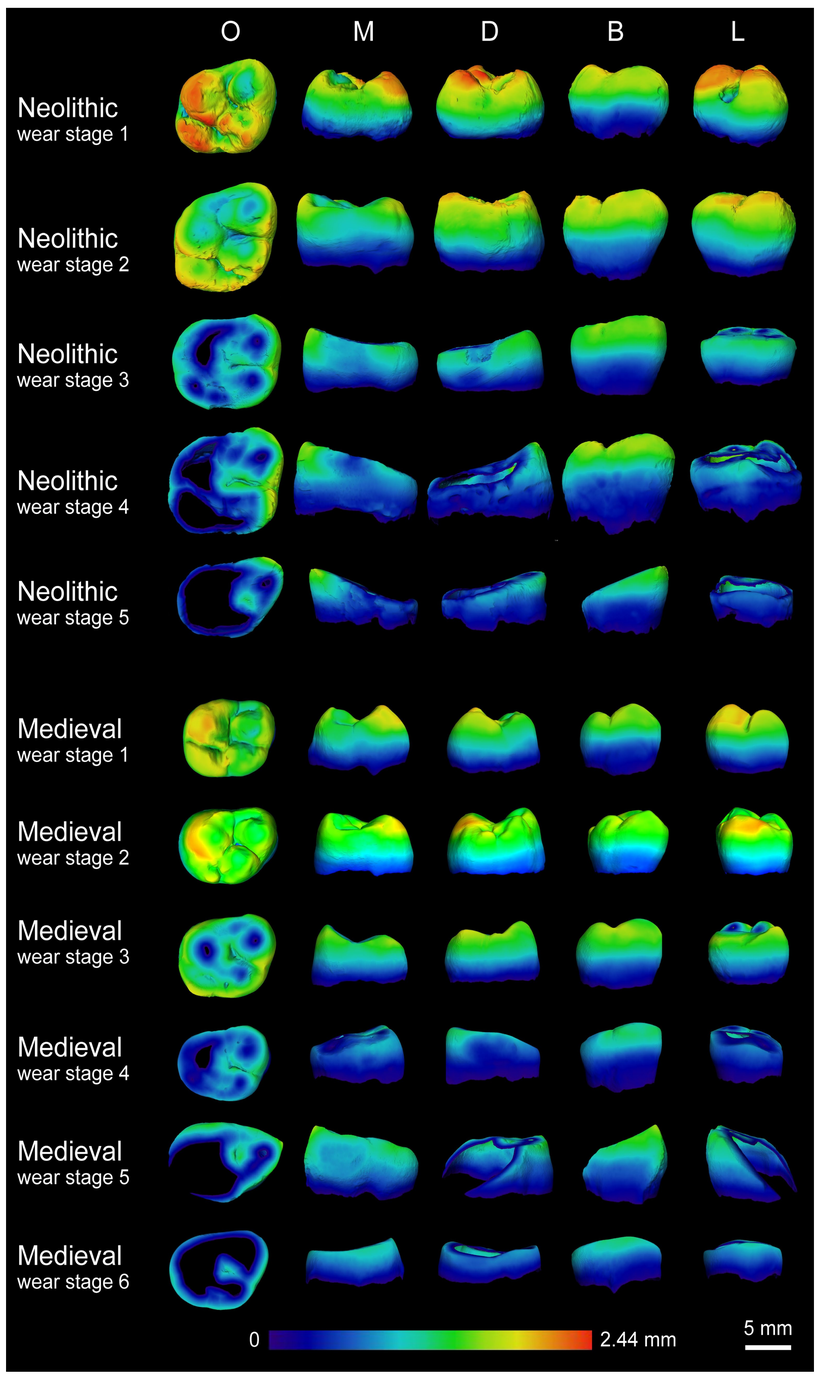

Figure 3. Comparative ET cartographies of Neolithic and Medieval crowns realized for each occlusal wear stage[6]. Topographic variation is rendered by a tooth-specific thickness-related scale ranging from dark blue (relatively thinner enamel) to red (relatively thicker enamel). Independently from their original side, all teeth are shown as left in occlusal (O), mesial (M), distal (D), buccal (B) and lingual (L) views.

Neolithic 2D AET and 2D RET are thicker than those of the Medieval sample. Maximal ET is found on the lingual cusps of Neolithic and Medieval UM2s, but Neolithic teeth show slightly higher ET values than those of Medieval crowns (Figure 3).

While the repartition of enamel is more homogeneous between Medieval lingual cusps, Neolithic molars systematically show a high dominance in ET in their distolingual position (Figure 3). For the Neolithic sample, maximal ET is precisely located where occlusal wear is the most important.

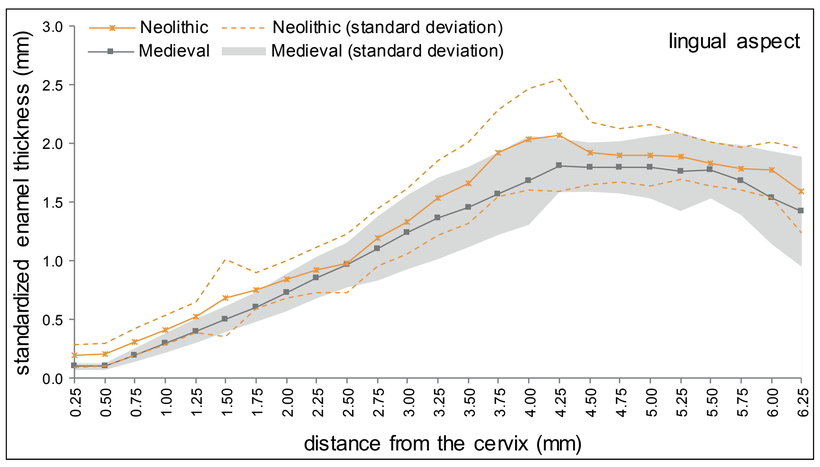

Figure 4. Topographic variation of standardized ET on the lingual aspect of the buccolingual section through the mesial cusps of Neolithic and Medieval UM2s.

For both Neolithic and Medieval UM2s, ET on the lingual aspect of the crown (Figure 4) is globally higher (about 2.5 mm) than on the buccal aspect (about 1.5 mm, Figure 5). Neolithic teeth have thicker enamel than Medieval crowns in both the buccal and lingual sides of the UM2s, but the difference is most pronounced on the lingual side.

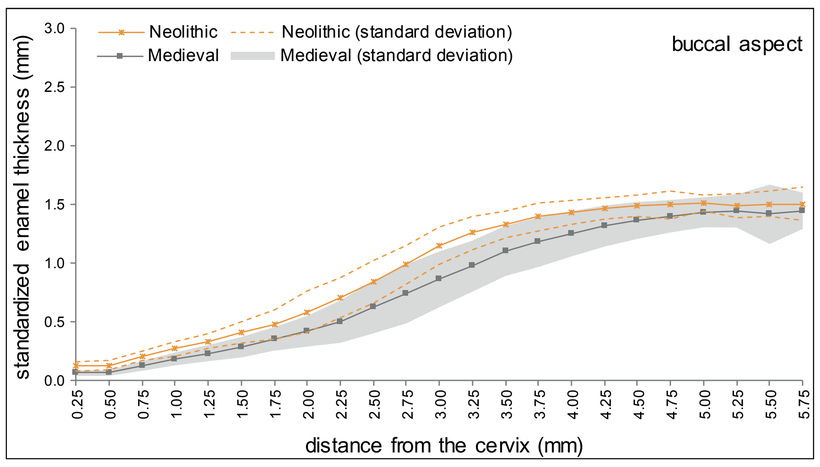

Figure 5. Topographic variation of standardized ET on the buccal aspect of the buccolingual section through the mesial cusps of Neolithic and Medieval UM2s.

Results of this study show that Neolithic UM2s have thicker enamel than the Medieval sample. While both Neolithic and Medieval molars share a general enamel pattern, differences have been found in occlusal wear and the topographic repartition of enamel thickness. This population of Neolithic European farmers with buccolingually directed oblique molar wear has maximal ET on the distolingual cusp of the maxillary crowns. Under strong genetic control, ET could rapidly evolve in response to functional dietary changes[3] and could be an adaptation to both dietary wear and a hard diet[4]. As already suggested, thick enamel is advantageous to sustain high masticatory loads and resist wear[1,2,4]. Our results show that thicker enamel on lingual cusps is associated with buccolingually directed oblique molar wear. This relatively thicker enamel may have evolved as a means to resist wear rather than a response to high masticatory regimes. In this respect, ET may be selectively responsive to occlusal wear. Additional studies will focus on selection forces acting on ET patterns and will provide additional guidelines for the evaluation of adaptive value of ET.

BIBLIOGRAPHY

[1] Molnar, S. and Gantt, D.G. 1977. Am. J. Phys. Anthropol. 46, 447-454.
[2] Scwhartz, G.T. 2000. Am. J. Phys. Anthropol. 111, 221-244.
[3] Hlusko, L.J. et al. 2004. Am. J. Phys. Anthropol. 124, 223-233.
[4] Pampush, J.D. et al. 2013. J. Hum. Evol. 64, 216-224.
[5] Smith, B.H. 1984. Am. J. Phys. Anthropol. 63, 39-56.
[6] Molnar, S. 1971. Am. J. Phys. Anthropol. 34, 175-190.
[7] Martin, L. 1985. Nature 324, 260-263.
[8] Olejniczak, A.J. et al. 2008. J. Hum. Evol. 55, 12-23.
[9] Beynon, A.D. and Wood, B.A. 1986. Am. J. Phys. Anthropol. 70, 177-193.
[10] Macchiarelli, R. et al. 2007. In: Vandermeersch, B. and Maureille, B. CTHS, 169-179.

ACKNOWLEDGEMENTS

Research supported by the DHP project (2012-14; dir: S. Rottier; Université Bordeaux 1 and LaScArBx - ANR program of prospects investments ANR-10-LABX-52). Mona Le Luyer benefits from doctoral grant of the Université Bordeaux 1. We thank Renaud Lebrun and the MRI platform (Montpellier RIO Imaging, Université Montpellier 2). We are grateful to Luca Bondioli, Christopher Dean, Dominique Henry-Gambier and Roberto Macchiarelli for discussion. Thanks to Clément Zanolli.