Prehistoric dentistry? P4 rotation, partial M3 impaction, toothpick grooves and other signs of manipulation in Krapina Dental Person 20.

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Abstract

Aims: We describe four associated mandibular teeth, left P4 – M3, which show a number of features consistent with a diagnosis that toothpick grooves and other dental manipulations were associated with treating multiple eruption abnormalities. **Materials and Methods:** The four isolated teeth making up Krapina Dental Person (KDP) 20 were analyzed by eye and with a light microscope to document occlusal wear, toothpick groove formation, ante mortem enamel, dentin scratches and lingual fractures. **Results:** Definitive, stage 4 toothpick grooves (1) occur on all four teeth, but are especially marked on both mesial and distal faces of the left P4 (tooth #32) and the mesial face of the left M1 (tooth #82). Less distinct interproximal grooves, defined as stage 2 striations, appear on the distal face of left M1, distal lingual edge of M2 (tooth #3) and the mesial face of M3 (tooth #8). The left P4 also shows signs of dental probing on the mesial buccal cusp and all four teeth have fractures on their lingual margins. These features are associated with malpositioned left P4 and a left M3 with lingual rotation and a crown that is partially impacted. The M3's buccal face occupies an occlusal position and shows considerable wear, indicating it was in approximation with the upper dentition. **Conclusion:** The anomalous dental eruption features of the P4 and M3 are associated with several kinds of dental manipulations, which seem to have been palliative measures to "treat" the dental problems. We consider this a kind of "prehistoric dentistry."

Keywords: interproximal grooves; 'premolar problem'; rotated, impacted M3; palliative actions

Introduction

Numerous studies have documented toothpick grooves in recent and fossil dentitions. From work on recent dentitions various authors have documented the presence of these grooves, imbedded into the interproximal surfaces of mandibular and maxillary permanent teeth from North America, Europe, Africa, Asia, Australia and the Pacific (2-9). Premolars and molars are the primary targets, but incisors and canines are sometimes involved and attributed to fiber processing when they are combined with grooves in the occlusal surface (10). We are unaware of any grooves in deciduous teeth or in non-*Homo* taxa (11). This habit is extended as far back as the earliest *Homo* in Africa (12), but also to a wide variety of later *Homo* from Europe and Asia (1,13-18) While some have contended causes other than palliative measures such as fiber processing and saliva jetting (8,19,20), they are most commonly associated with periodontal disease or caries in modern groups. Yet, they also occur with no signs of oral pathology, so they may be idiosyncratic, the product of a nervous behavior or without a determinable etiology. Multiple materials have been proposed to account for the formation of the grooves, from bone to grass stems (1,21) and, again, given their widespread geographic occurrence and their appearance in hunter-gatherer and agricultural groups, it is unlikely a single type of instrument was the cause.

The tooth set KDP 20. Krapina Dental Person (KDP) 20 is represented by four mandibular teeth. Wolpoff (22) assembled many of the Krapina isolated teeth into tooth sets, which he called a Krapina Dental Person. He based these associations on similar morphological features, occlusal wear and, especially, interlocking interproximal facets. Consisting of P_4-M_3, he originally labeled this specimen as mandible M (22), but later in the Krapina Catalog (23), it was re-labeled as KDP 20. The specimen is interesting because it shows evidence of a buccally displaced P_4, a partially impacted, lingually rotated M_3, a number of toothpick grooves in the interproximal spaces of all four teeth (16), a series of scratches on the superior labial surface of P_4 and what appear to be ante mortem lingual chips on at least M_1-M_2. Added together these features suggest that the Krapina Neandertal (KDP 20) was having dental irritation or pain associated with the abnormal tooth eruption and was attempting palliative maneuvers through toothpicking, dental probing and, maybe, other more drastic measures.

Dental state. The P_4-M_3 set shows some occlusal wear (Figure 1a). P_4 has polishing of the labial and lingual cusps, but no dentin exposure. M_1 is the most worn with flattening of all the occlusal cusps and dentin exposure on all cusps, but especially the entoconulid (cusp 4) and the hypoconulid – cusp 5 (24) that are highly polished. The M_2 has only flattening and polishing of the occlusal cusps plus very faint dots of dentine exposure on two mesial cusps (protoconid, cusp 1, and metaconid, cusp 2). M_3 is anomalous in that the crown surface is rotated lingually, so that the top half of the buccal face is in the occlusal plane. Rotation of the tooth results in no wear on the lingual aspect of the occlusal surface, which was has been completely twisted, inferiorly out of the occlusal plane. According to Wolpoff (22) KDP 20 is 19, but the individual may have been older at death based on the depth of the toothpick grooves and the occlusal wear on M_3. In any event, age at death of KDP 20 does not affect our diagnosis.

Interproximal grooving. As described by Frayer and Russell (16) the four teeth making up KDP 20 have a total of six toothpick grooves: two each on the mesial and distal faces of P_4 (#32) and M_1 (#82), one on the distal of M_2 (#3) and one on the mesial of M_3 (#5). Grooves on the distal M_1 and M_2 and mesial M_3 are very faint compared to the deep grooves on the P_4 and mesial M_1 (Figure 2). We scored them as stage 4 (1). These grooves have been described in detail for KDP 20, so we limit our description of them. The most impressive is the long, deep groove running along nearly the entire cervical, mesial border of M_1 (#82). (Figure 2a). This groove is highest on the buccal edge and tapers lingually, suggesting the toothpick was inserted buccally and used repeatedly given the depth of the groove. Areas with cementum build-up occur below the groove and striations within the groove suggest the tool was inserted in a back

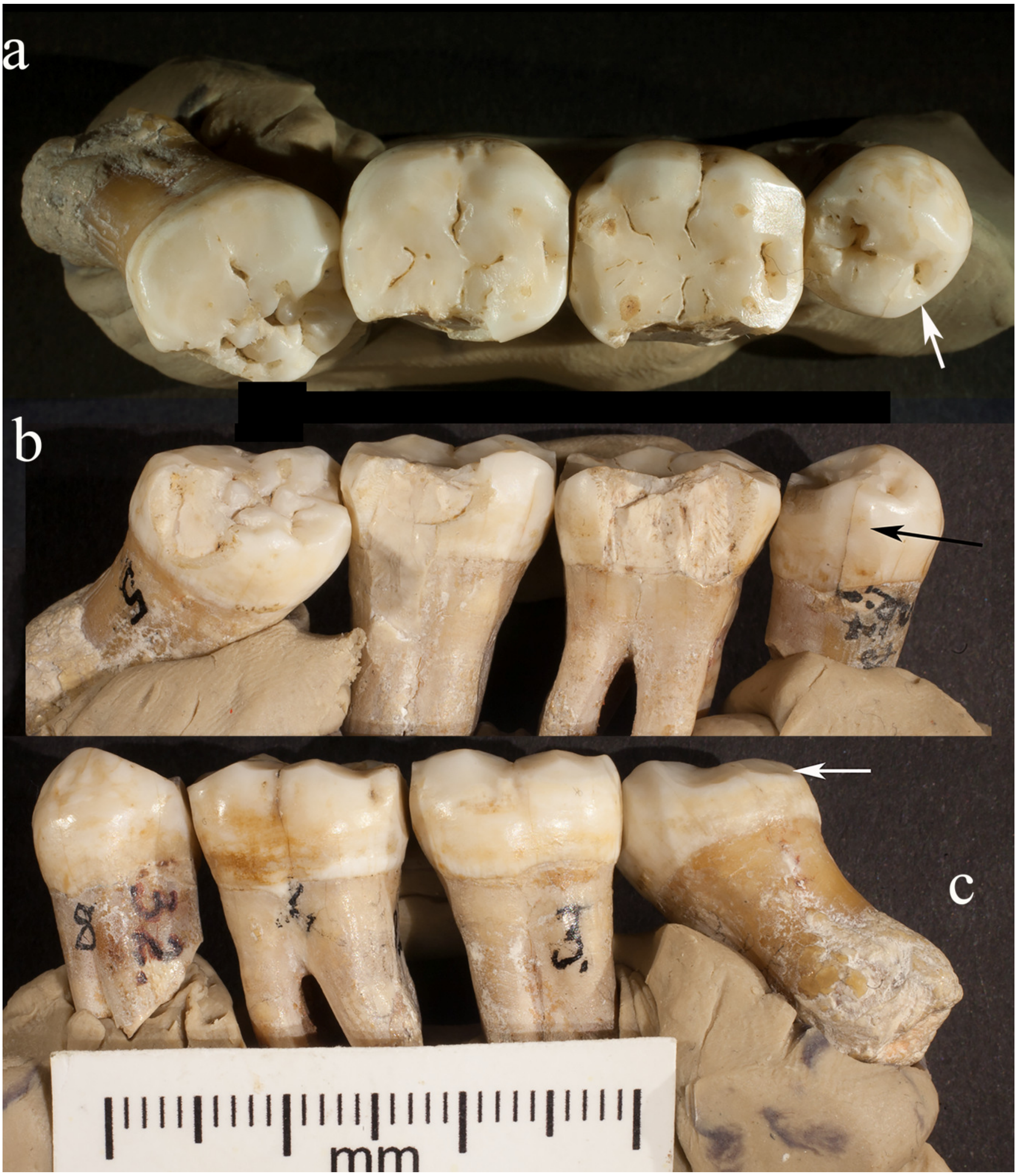

Figure 1. Three views of the four articulated teeth making up KDP 20. a. occlusal view showing lingually placed mesial interproximal wear facet on P4 (arrow) and buccal wear on M3; b. lingual view showing a mesially placed interproximal wear facet on P4 (arrow), chips from lingual faces of all teeth and rotated, partially impacted M3; c. buccal view showing rotated buccal face of M3 (arrow) and hypercementosis on its root.

and forth, horizontal action. A much less distinct groove occurs on the distal face of #82. Consisting mainly of polishing below the cemento-enamel junction, we classify this as a stage 2 groove. (Figure 2b) Mesial and distal grooves on the left P_4 (#32) are stage 4 and impressive in their extent and depth (Figure 3a, b). The distal groove does not run across the entire distal face, but is confined to the lingual-most edge. Unlike the matching groove on the M_1, this groove is considerably shorter and confined to the lingual half of the P_4's cervical border. The groove is more angled than the one on the mesial M_1 and widest lingually. The wide gap between the P_4's distal face and the mesial face of M_1 allowed for a large interproximal opening, which may account for the different orientation of the toothpick grooves in the P_4 and M_1. It may be that this groove was produced by a different action than the mesial interproximal groove on M_1. In tooth #32 the mesial interproximal facet is the smallest of the three. Like the mesial M_1 groove, it runs horizontally across the mesial face, but extends over only the lingual third of the root and is oval in shape. Signs of interproximal grooving are much less pronounced on the M_2 and M_3. For the M_2 (tooth #3) there is a small facet on the lingual edge of the distal root face, which is a faint toothpick groove. This corresponds to a polished area on the enamel of the mesial face of M_3 (tooth #8). Both of these are little more than polishing of the surface and represent a stage 2 expression (1).

Rotated P_4. As described by Rougier et al. (25) four Krapina mandibles show rotated P_3s, all from the left side, based on teeth or angled root sockets. When teeth are preserved, there are no associated toothpick grooves in any of these specimens. They briefly described KDP 20 (25) and argued that the mesial interproximal facet on the P_4 "can only be explained by a clockwise rotated P_3 whose lingual face was in contact with the fourth premolar" (p. 276). We disagree with this interpretation. In our view the P_4 mesial interproximal facet occupies a very lingual position, well off the center of the mesial face (Figure 3a, b). In the rotated P_3's of other Krapina specimens (especially, KDP 4, 10, and 28) the mesial interproximal facet is buccally oriented. In KDP 20 when the distal facet is articulated with the M_1, the P_4 protrudes buccally from the lateral plane defined by the M_1 and M_2, as shown in Figure 1a. The combined positions of the mesial and distal interproximal facets suggest this is an example of P_4 malposition. This occurs on the left side as in all of the other rotated mandibular premolars at Krapina. The buccal positioning of the P_4 is consistent with the shape and orientation of the deep interproximal grooves on it.

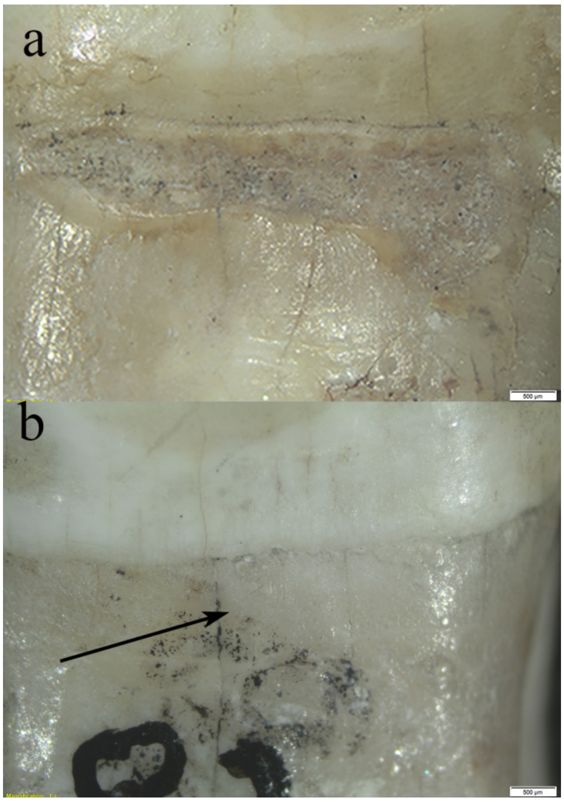

Figure 2. Toothpick grooves on the left M1. a. mesial view of a deep toothpick groove running across the entire cervical margin; b. distal surface showing polished surface (arrow) representing a shallow toothpick groove.

Partially impacted and rotated left M_3. This tooth is clearly rotated from its normal position so that most of the normal occlusal plane faces lingually. The occlusal lingual cusps are unworn, while the buccal surface of the tooth shows considerable wear (Figure 1a). Dentin is not exposed on this buccal face, but there are two large wear facets on the mesial buccal and distal buccal cusps. These are 'cratered' and the buccal face enamel is definitely polished and thinned, so that it is translucent (Fig. 1a/c). Other evidence for this rotation consists of the abnormal condition of the interproximal facets on the distal M_2 and mesial M_3.

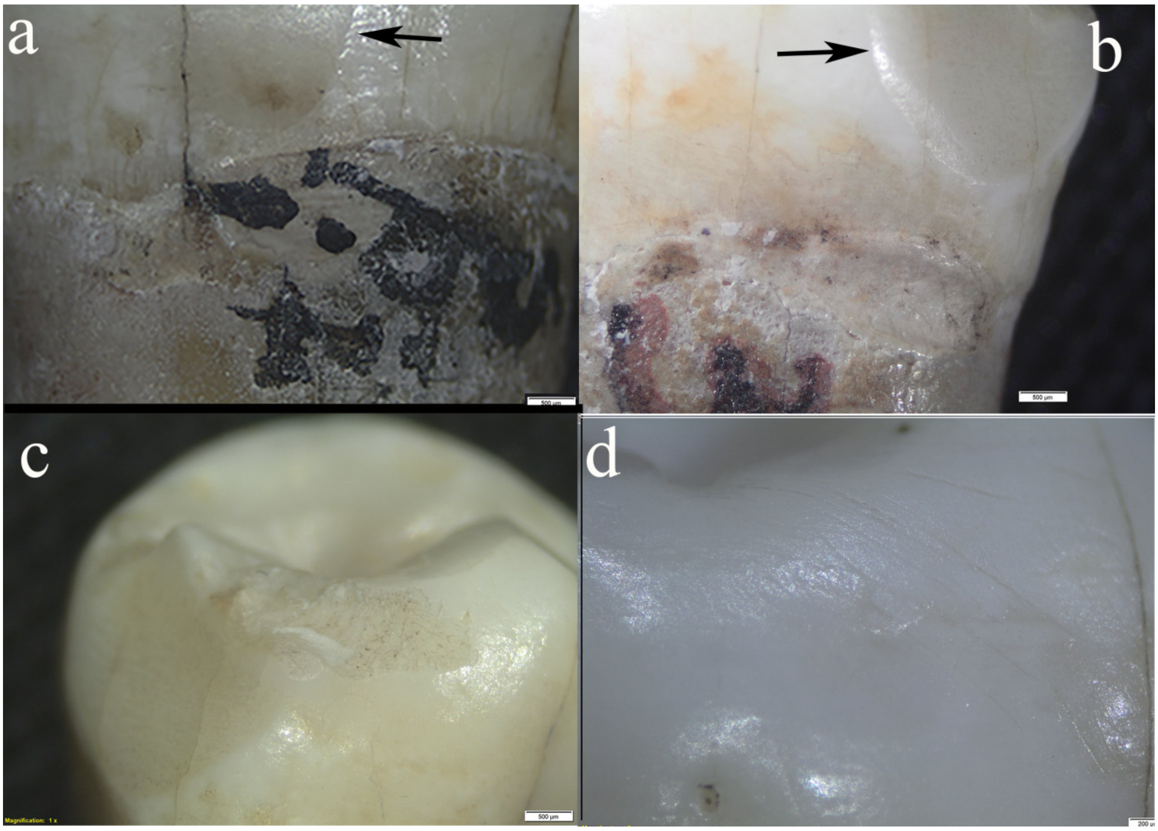

Figure 3. Toothpick grooves, irregular interproximal facets and other anomalies on the left P4. a. mesial face with a small toothpick groove on the mesial-lingual edge. Above it is a very lingually positioned interproximal wear facet (arrow); b. distal surface with a deep toothpick groove and an interproximal wear facet that has an abnormal lingual location (arrow); c. chips from the occlusal/lingual margin; d. probing striations on the mesial/buccal facet.

On the M_2 the distal facet is lingually oriented and deeply etched into the enamel so that the dentin is almost exposed. The matching mesial interproximal facet on the M_3 is superiorly positioned so that it is contiguous with the occlusal face. When articulated with the M_2 interproximal facet, the normal occlusal face is oblique, tilted lingual to the occlusal plane (~45º) and the buccal edge is the new occlusal face. From the depth of the interproximal facets on M_2 and M_3 it is clear that these teeth rocked against each for some time producing the deep gouges in both surfaces. While the sample is small, KDP 20 is the only specimen from the site with a mal-aligned P_4 and a rotated, partially impacted M_3.

P4 scratches. In addition to the toothpick grooves in the interproximal space, this tooth shows a series of scratches on the face of the mesial buccal cusp. (Figure 3c) At least ten striations run up the buccal face, from below the occlusal surface to its face. These run from the mesial face to the occlusal surface and are wider and deeper than scratches produced by dietary items. They are roughly parallel, oblique to the occlusal plane and resemble striations found on the Krapina Neandertal incisors and canines (26). These scratches were produced by some hard probe, which was inserted into the mouth and rubbed against the mesial face of the P_4 crown.

Lingual chipping. All four teeth show chips removed from the enamel on the lingual edge. The smallest are two small chips missing from the distal lingual edge of P_4 (Figure 3b). Chipping of the M_1 and M_2 is much more extensive and completely limited to the lingual side. For the M_1 the whole lingual face is missing from the occlusal surface to the cervical border. The break barely extends to the root surface on its most mesial aspect (Figure 1b). The lingual break on the M_2 is smaller than on the M_1 with the broken surface starting from the midpoint of mesial lingual cusp (Figure 1b). The break continues to the distal interproximal facet and extends down the root some 5mm below the cervical border. This lingual break has a wide U-shape, similar to the break on M_1. For M_3 there is a chip missing from the distal lingual edge. This chip is different from the ones on the M_1 and M_2 in that it is confined to the crown and more obliquely angled (Figure 1b). In every specimen, the impacts causing the missing sections were delivered to the occlusal face and spalled off the lingual edge. There are clear impact fractures with spalling of the more inferior portions, whether on the enamel or root. The exposed surfaces on all the molars show smooth dentin surfaces and are without surface scratches. The surfaces have a creamy appearance as if the dentin was stained, but this could be due to discoloration from cave sediments. There are secondary chips from the fractured edges, especially on the M_1 and M_2. On the M_1 the occlusal-most edge of the lingual fracture shows microchips with smoothing and other signs of wear along its border (Figure 4a). On the M_2 secondary microchipping occurs within the primary fracture and the edges are smoothed and polished. (Figure 4b) Another aspect of the lingual chipping is the different angulations of the chips removed from the surface. On the P_4 the chips are small and angled at ~45º to the occlusal plane. The large chip removed from the M_1 shows a completely vertical orientation with spall fractures at the lingual, cervical border. On M_2 the chip is also vertically placed, but is more distally oriented and on the M_3 the chip is confined to the crown on the distal/lingual surface and slightly angled to the occlusal plane. (Figures 1a & b) The M_3 chip shows no polishing. These chips were removed in separate actions and, especially on the M_1 and M_2, appear to be ante mortem. While it is unclear what caused the lingual chipping, it happened before the death of the KDP individual.

Roots. All teeth show some root damage. The most extensive is the P_4 with at least half of its root missing. There is a sharp break across the root from the lingual to the buccal side. The exposed surface appears lighter than the breaks on the molar surfaces and there are a few patches of hypercementosis, especially on the mesial aspect. M_1 shows some slight damage to the mesial root tip and the inferior ends of the mesial and distal roots show hypercementosis. M_2 has the base of the root broken away, exposing the inferior pulp canal. The root surfaces are smooth and free of hypercementosis. The M_3 shows some damage to the inferior-most root, but this area is covered with hypercementosis, which is mostly confined to the root tip (Figure 1c). Adhering cave sediment obscures the root tip. None of the roots bear evidence of surface erosion or pitting associated with periodontal disease.

Discussion. The oldest toothpick grooves discovered so far occur in the isolated left and right P^3s of a *Homo habilis* specimen from Omo (L894-1a/c) dated at 1.84 mya (12). These are nearly matched in age by the isolated right M_3 (OH 60) from Olduvai Gorge dated between 1.7-2.1 mya (11). In this specimen, a single interproximal groove occurs on its mesial face. As in the Omo teeth, there are no signs of pathology. Later *Homo* specimens from Dmanisi (15), Sima del Elefante (14) and Konso (27) are dated between 1.77-1.42 mya. Of these latter cases the involved teeth are still located in jaws and each mandible shows signs of periodontal disease. Dmanisi mandible D2735 has a right M_1 with a distal toothpick groove and "local marginal periodontitis" (15) (p. 17280). Sima del Elefante ATE 9-1 has signs of alveolar pitting and it has a deep toothpick groove on the P_4. Konso 10-1 has multiple toothpick grooves on its P_4-M_3 with associated periodontal disease (27). A few other cases of toothpick grooves occur among Neandertals, such as Cova Forada 28 and Banyoles 17, which also show signs of periodontitis.

None of these specimens involve impacted teeth and, indeed, impacted teeth are rarely found in the human fossil record. There are two cases in Neandertals, both involving anterior teeth, but neither have an occlusal eruption.

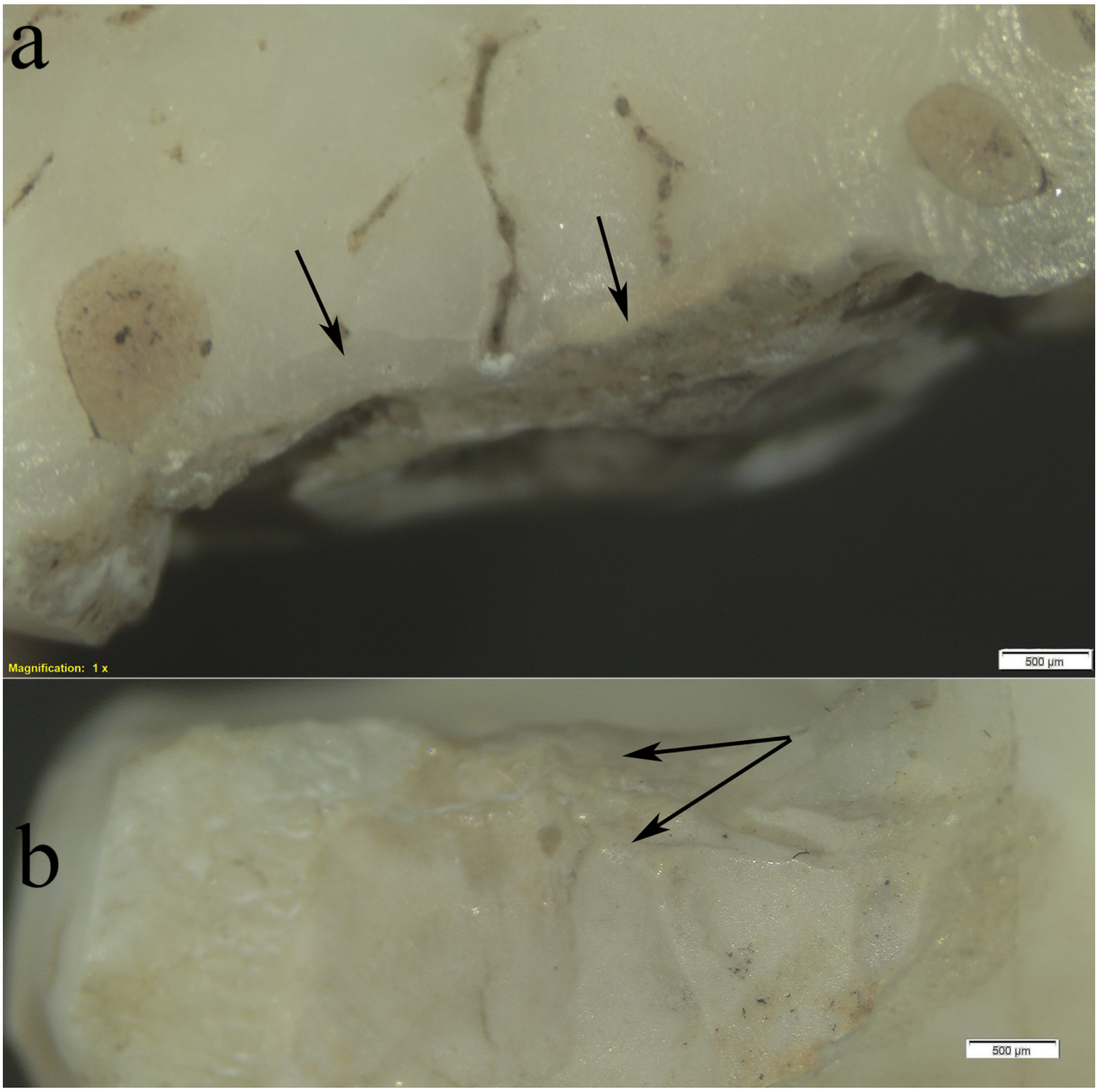

Figure 4. Ante mortem wear on broken edges of teeth #82 and # 3. a. view from the occlusal perspective of the M1 with arrows indicating segments of polishing and smoothing after the main chip was removed. Brownish circular patches on the occlusal surface are dentin exposures from wear. b. lingual view of the M2 with arrows showing polished and smoothed surfaces on the secondarily flaked edge.

The Moustier 1 mandible is estimated to date to about 40 kyrs ago and is thought to be a 15.5 year old male (29). As described by Bilsborough and Thompson (30) the left permanent canine is impacted below the alveolar border and is associated with a retained, heavily worn left deciduous canine. In Le Moustier 1 there are no toothpick grooves or other signs of dental manipulation, but the deciduous canine experienced heavy, anomalous occlusal wear. The second case of a Neandertal impacted tooth comes from El Sidròn 2, where an adult, left mandible shows a horizontally placed permanent canine crown and root well below the root apices of the left M_3 (31). Like in Le Moustier 1 the left deciduous canine is retained in its occlusal position. Given its anomalous position in the mandibular corpus, this permanent canine would never have erupted. Toothpick grooves

occur on the right I_1 and on the associated right I^2, but these are unrelated to the impacted canine (1).
In KDP 20 we do not have the mandibular bone to check for other dental problems and periodontal disease, but these four isolated teeth exhibit evidence that a Neandertal made attempts to 'treat' the rotated P_4 and partially impacted M_3. Even without the bone, we can propose that the six toothpick grooves, the scratches on the P_4 and, possibly, the lingual chips on all four teeth are the result of attempts to get at the pain and irritation of the dental eruption problems involving the misplaced P_4 and, especially, the partially impacted M_3.
The cause of the lingual chipping is the most difficult to explain. One could argue that the broken surfaces are due to post mortem causes, --- the result of trampling, cave sediment damage or carnivore activity. But, we rule these out since the broken lingual edges are at different angles to each other and appear to have occurred at different times. We expect carnivore damage would be more organized, occurring in single incident and leaving a more consistent pattern of damage. The same is expected for trampling or sediment damage. There are also secondary fractures within the primary fractured surfaces on the M_1 and M_2 and smoothing and polishing occur on the occlusal-most portions of the fractured areas. These are signals that the breaks are ante mortem. The most likely factor accounting for the main lingual fractures is normal mastication. In modern dentistry mandibular posterior teeth commonly show chipped lingual margins, mainly the result of chewing forces. For example, Bader, Martin and Shugars (32) found in a large clinical sample that lingual cusps of mandibular teeth showed incidence rates for noncarious fractures (fractures/1000 teeth/year) of .4 for P_3, 3.1 for P_4, 15.1 for M_1, 7.7 for M_2 and 4.0 for M_3. On a per/tooth basis these represent 1.8 % for P_3, 14.1% for P_4, 48.5% for M_1, 30.7% for M_2 and 4.9% for M_3. Clearly the molars are more likely to show lingual fractures than the premolars. They also found that the fracture "almost always exposed dentin" and that occasionally the fracture extended below the cemento-enamel junction, as in tooth #82 and #3. Surveying Inuit and two Medieval samples from Norway and Spain, Scott and Winn (33) came to similar results, in that the posterior teeth, especially M_1 and M_2, were more likely to have ante mortem fractures in the Inuit hunter-gatherers. In a review of 15 skeletal samples Milner and Larsen (34) reported more involvement of the posterior teeth and common lingual surface chipping in the mandibular molars.
Following Milner and Larsen's suggestions for separating ante mortem from post mortem, the broken lingual faces show ante mortem changes, especially near the occlusal border. On the M_1 and M_2 secondary fractures, blunting and smoothing occurs on the broken occlusal edges. We think this damage occurred before death, but given its limited extent there was little time between the breaks and the death of the KDP 20 Neandertal.
From the toothpick grooves and scratches on the mesio-buccal edge of the P_4, it is possible there was some kind of intervention in an attempt to 'treat' the dental problems by removing the lingual edges, but we think it is more likely the fractures occurred due to chewing stress. However, such interventions should not be unexpected given other evidence that Neandertals used plants for self-medication (35). In a recent study of plants consumed by the El Sidrón Neandertals Weyrick et al. (36) found small percentages of genetic sequences of a natural painkiller (poplar) and penicillin (fungal components) in the calculus of El Sidrón 2. El Sidrón 2 also has two large, draining abscesses on the right mandible --- one under the I_2 root and the other below the roots of P_4 and M_1. While many different animals self-medicate (37), most of these relate to treatment for parasites and none have been documented for a dental infection. It seems likely that as more Neandertal calculus is analyzed, especially in specimens with dental pathologies, other examples will be found where Neandertals are using natural products to alleviate dental pain and infection. We have no similar paleogenetic data for KDP 20; some remnants of calculus are present, but these have not been analyzed.

Conclusion.
The individual represented by KDP 20 appears to have been making a direct, mechanical approach to her (his) problems of the mis-alignment in the P_4 and the partial impaction of the M_3. The toothpick grooves and enamel scratching on the P4 seem to be aimed at these problems, with very distinct tooth pick grooves on the mesial and distal surfaces of the P_4 and the mesial face of M_1. Lingual breaks on all four teeth are more difficult to interpret, but some are clearly ante mortem and are likely related to altered masticatory

forces related to the two mis-aligned teeth. However, given the other interventions, it is impossible to rule out that these fractures were intentionally done to 'treat' the irritation caused by partially impacted M_3.

Acknowledgements
We want to especially acknowledge Milford Wolpoff's contribution to our work with KDP 20. Nearly 40 years ago, the isolated teeth were uncataloged and in separate boxes in the Croatian Museum of Natural History. Wolpoff convinced the director, Ivan Crnolatac, to consecutively number the almost 200 isolated teeth and combine them into one collection for easier analysis. Wolpoff was able to assemble some of the isolated teeth into associated units or tooth sets, a kind of scientific lego reconstruction. Without his contribution, our work would have not been possible. We thank Luka Mjeda (Zagreb) for Figure 1.

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