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Dental crowding in a prehistoric population

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SUMMARY The aims of this study were to investigate dental crowding from the Copper Age and examine the extent and patterns of wear. Crowding was estimated in 43 adult mandibles using Little's irregularity index. Dental wear, dental diameters, arch width and the presence of third molars were also studied as possible aetiological factors for crowding. The remains were found at the archaeological site of Roaix, located in the south of France. Radiocarbon dating indicated that the lower layer was from 2150 ± 140 years BC (date ±1 standard deviation) and the upper level from 2090 ± 140 years. The graves were estimated to contain the remains of 150 adults and 50 children. Forty-three intact mandibles were used for this study.

All of the mandibles presented incisor crowding with a majority of minimal and moderate irregularities, but in seven cases there were extreme irregularities and in two canine impaction was observed.

These results are in contrast with the literature where it is reported that malocclusions were rare in prehistoric populations. The findings of this study suggest that crowding may be of a genetic origin and might not be caused by excessive tooth size or changes in environmental factors (masticatory activity).

Introduction

Dental crowding is nowadays one of the most frequent dental anomalies, with a population prevalence of 70–80 per cent (Little, 1975; Proffit *et al*., 1998). According to Andrik (1963), malocclusions were rare during the Palaeolithic period. That author noted a crowding prevalence of only 1 per cent from the Bronze Age and 10 per cent in a 16th century population. Since medieval times, an increase in malocclusions has been reported, after having shown relatively modest changes for 6000 years (Smyth, 1934; Brash, 1956; Helm and Prydsö, 1979). However, the work of Harper (1994) showed that the irregularity of modern teeth was less pronounced than that in a medieval skull sample.

Theories proposed to explain the cause of dental crowding vary widely, embracing concepts such as evolution, heredity and environmental factors (Van der Linden, 1966; Lombardi, 1982; Kiliaridis *et al*., 1985; Fränkel and Löffler, 1990; Harris and Johnson, 1991; Mossey, 1999).

The aim of the present study was to document prehistoric dental crowding and canine impaction from the Copper Age in the south of France, specifically the archaeological site of Roaix. This prehistoric population frequently presented crowding, which was sometimes very severe, distinguishing it from previous findings. Indeed, such severe crowding (and its unusually high prevalence) does not appear to have been reported previously in a prehistoric population.

The specific aims were:

1. to estimate the prevalence and the severity of dental crowding in prehistoric human skeletal remains from the Copper Age;
2. to study the dental wear, tooth size, arch width and presence of third molars as possible aetiological factors of crowding;
3. to consider the probable reasons for the findings.

Material and methods

The archaeological site of Roaix, located in the south of France, was discovered in 1966. This site was a mass grave containing remains from the Copper Age buried in two sepulchral layers separated by a sterile one. Radiocarbon dating indicated that the lower layer was from 2150 ± 140 years BC (date ±1 standard deviation) and the upper level from 2090 ± 140 years BC. The individuals were farmers and the minimum number of individuals was estimated at 150 adults and 50 children (Courtin, 2000).

The skeletal remains examined in the present study were archived in the Anthropology Laboratory of Marseille Medical School (Northern sector, Mediterranean University). The osseous material was in a variable state of conservation: skulls and maxillae were particularly damaged, whereas the mandibles were well preserved. Crowding was estimated in 43 adult mandibles; the other individuals were not suitable for investigation due to post-mortem alterations.

Whenever possible, sex and age were determined using the method described by Ferembach *et al*. (1980) and by the cranial sutures and/or eruption status and attrition patterns of the molar teeth (Miles, 1963). Among the 43 mandibles, 22 belonged to young subjects (12–24 years of age), 10 to medium-aged subjects (25–36 years) and six to older subjects (older than 36 years).

The age of five adult mandibles could not be determined. Sex could not be determined for these individuals, but it can be supposed that the grave included both men and women as a survey of 26 individuals in whom gender could be determined showed 14 men and 12 women (Courtin, 2000).

Dental crowding

Crowding was estimated using Little's (1975) irregularity index. This index represents the linear displacement of the anatomic contact points (as distinguished from the clinical contact points) of each mandibular incisor from the adjacent tooth's anatomical point—the sum of these five displacements representing the relative degree of anterior irregularity. Little (1975) established a classification of the index scores by distinguishing ideal alignment (0–0.9 mm), minimal (1–3.9 mm), moderate (4–6.9 mm), severe (7–9.9 mm) and extreme (more than 10 mm) irregularities.

Measurement error. The irregularity index was measured by one examiner using a dial calliper calibrated to the nearest 0.01 mm. The measurements were carried out on two separate occasions with approximately 2 weeks between the readings. The error of the method was investigated using analysis of variance. The mean differences were less than 0.3 mm. For an acceptable method error, the variance ratio of the difference of the two measurements should be below 10 per cent of the variance of the first set of measurements. None of the measurements exceeded this percentage.

Dental wear

The 43 mandibles of the Roaix population were considered as fully dentate. Thus, 676 teeth were separately examined, including 172 incisors, 84 canines, 170 premolars and 249 molars. In order to derive an approximate assessment of the degree of dental wear, a slight modification of the classification system of Davies and Pedersen (1955) was used (Brabant and Twiesselmann, 1969; Lavelle, 1973a). Thus, each tooth was graded according to the following categories: stage 0 = no wear; stage 1 = wear of the enamel only; stage 2 = wear of the dentine, the occlusal face presents more enamel than dentine; stage 3 = wear of the dentine, the occlusal face presents more dentine than enamel; stage 4 = advanced wear stage, near the pulp and beyond.

Measurement error. To assess the significance of the error involved in dental wear measurements, a series of 20 mandibles was reassessed 2 weeks after the initial measurements had been made. Repeat measurements showed that any error in the technique of assessment was unlikely to have had any material effect upon the results of the comparisons.

Tooth size

The mesiodistal diameters of the incisors (I1, I2), the canines (C), the premolars (P1, P2), the first and second molars (M1, M2) were measured.

Arch width

The intercanine width was measured from the mandibular cusp tips. In cases of marked occlusal wear, the presumed centre of the cusp was used.

Third molar presence

An occlusal radiographic examination was undertaken when third molars were absent.

Results

Dental crowding

The findings concerning crowding are summarized in Tables 1 and 2 and compared with studies of historic and modern Caucasian populations. The prevalence of crowding was 100 per cent in this prehistoric population. Thus, all 43 adult Roaix mandibles presented incisor crowding, with the majority showing minimal or moderate irregularities, with seven subjects with extreme irregularities (Figure 1). Furthermore, two canines were impacted in two individuals (Figure 2). A number of mandibles (which were not studied because

Table 1 Mean and standard deviations (SD) of dental crowding in the prehistoric population of Roaix (Little's index) compared with historic and modern Caucasian populations.

	Prehistoric population of Roaix		Historic population of the 19th century (Vyslozil and Jonke, 1994)		Modern population (Vyslozil and Jonke, 1994)	
	Mean	SD	Mean	SD	Mean	SD
Crowding (mm)	6.3	4.5	2.7	2.6	3.9	2.4

Table 2 Irregularity scores in the prehistoric population of Roaix (Little's classification) compared with a modern Caucasian population.

Crowding: class of severity	Prehistoric population of Roaix		Modern population (Proffit *et al.*, 1998)
	n	%	%
Ideal (0–0.9 mm)	0	0	33.7
Minimal (1–3.9 mm)	14	32.5	27.3
Moderate (4–6.9 mm)	15	34.8	23.3
Severe (7–9.9 mm)	7	16.3	11.4
Extreme (>10 mm)	7	16.4	4.3

Figure 1 Occlusal view of an adult Roaix mandible showing incisor crowding

Figure 2 Frontal view of an adult Roaix mandible showing crowding and impaction of 33. The left premolors (34, 35) were lost post-mortem

of significant *post-mortem* tooth loss) showed poor alignment of the dental sockets, which allowed assessment of crowding.

Dental wear (Table 3)

With the exception of three teeth, all the teeth of the 43 mandibles showed occlusal and incisal wear. In 65.6 per cent, the mandibular teeth showed wear of the dentine, which was excessive in 15 per cent of cases (stages 3 and 4). Stage 2 (moderate wear of the dentine) was more predominant.

Tooth size

The mesiodistal dental diameters for the lower teeth are presented in Table 4 and compared with standard dimensions in a modern Caucasian population (Brabant and Twiesselmann, 1969). A Student's *t*-test confirmed that the mesiodistal diameters of M1, P2, P1 and C were larger in the modern population than in the population of Roaix ($P < 0.05$). The differences were not significant for the mesiodistal diameters of I1, I2 and M2.

Table 3 Distribution of dental wear in the prehistoric population of Roaix.

Wear stage	Number of teeth	Percentage
Stage 0: no wear	3	0.4
Stage 1: wear of the enamel	230	34
Stage 2: wear of the dentine: the occlusal face presents more enamel than dentine	342	50.6
Stage 3: wear of the dentine: the occlusal face presents more dentine than enamel	97	14.4
Stage 4: advanced wear stage, near the pulp, and beyond	4	0.6
Total	676	100

Table 4 Mandibular tooth sizes (mm) in the prehistoric population of Roaix compared with the standard dimensions of a modern Caucasian population.

Tooth	Prehistoric population of Roaix		Modern population (Brabant and Twiesselman, 1969)
	n	Mean	Mean
Molars			
M2	86	9.75	9.96
M1	86	10.14	10.72
Premolars			
P2	85	6.17	6.56
P1	85	6.08	6.42
Canine			
C	84	6.15	6.63
Incisors			
I2	86	5.68	5.73
I1	86	5.39	5.20

Arch width (Table 5)

The mean lower intercanine width in the Roaix population was 24.6 mm; this was reduced when compared with arch widths in modern Caucasian populations (25.4–27.9 mm).

Third molars

The majority of the Roaix's mandibles presented M3 on the occlusal plane. Only five individuals had a bilateral *ante-mortem* absence of these teeth. Radiographic examination confirmed the displacement of third molars in two young adults. In the three other individuals the third molars were absent.

Discussion

In this study, the adults of the prehistoric population of Roaix all presented crowding localized to the lower incisors and canines, with canine impaction in two individuals. Crowding of the upper arch was not studied because the maxillae were significantly damaged, but mandibular incisor irregularity is often the precursor of maxillary crowding (Little, 1975). A previous study comparing crowding with Little's index between an historic population of the 19th century and a modern population showed a significant increase in crowding (+1.2 mm) in the modern population ($P < 0.05$) (Vyslozil and Jonke, 1994). The population of Roaix differs considerably from those data, crowding being clearly greater in this prehistoric population than in the population of the 19th century (+3.6 mm) and in the modern population (+2.4 mm) (Table 1). Furthermore, all the adults of this prehistoric population presented dental crowding, while crowding in the modern population has been reported to be 70–80 per cent (Sinclair and Little, 1983; Proffit *et al*., 1998). These findings are in contrast to the results of Andrik (1963) who reported that malocclusions were rare in prehistoric populations and noted a crowding prevalence of only 1 per cent from the Bronze Age. Therefore, the frequency and severity of lower incisor irregularity are atypical in the Roaix population. To date, this is the first time that such observations have been observed in a prehistoric population from the Copper Age.

In this study, the mesiodistal diameters of the lower teeth were similar to those of a modern population (Table 4). Indeed an increase in tooth size has been reported over the last 300 years (Brabant and Twiesselmann, 1969; Lavelle, 1973b). Thus, the crowding found in the Roaix population cannot be explained by excessive tooth size.

Several studies have shown that jaw development and dentoalveolar deviations are affected by environmental factors such as mouth breathing or masticatory and paramasticatory activities (Andrik, 1963; Corruccini, 1984; Fränkel and Löffler, 1990; Weiland *et al*., 1997), with masticatory function being the most frequently mentioned environmental factor (Hunt, 1966; Lombardi, 1982; Thilander *et al*., 1991). Kiliaridis *et al*. (1985) and Kiliardis (1986) showed a relationship between masticatory function and jaw development. In the present study, where dental wear was used as an indicator of masticatory function, the adults frequently showed wear of the dentine, which no longer exists in modern populations (Molnar, 1971). Brabant and Twiesselmann (1969) and Lavelle (1973a), who studied dental wear in prehistoric populations, showed equivalent dental wear levels to those of the Roaix population, i.e. a predominance of stage 2 (moderate wear of the dentine). Therefore, functional aetiology due to a less powerful masticatory function might not be relevant to the population of Roaix.

Mandibular incisor crowding is frequently attributed to mesial migration of the third molars (Fastlicht, 1970; Lombardi, 1982). In this study, the majority of the Roaix mandibles presented third molars on the occlusal plane. However, this aetiology is controversial in orthodontics because there is no scientific element proving the value of mesial migration of these teeth (Forsberg, 1988; Pirttiniemi *et al.*, 1994; Little, 1999). Moreover, five individuals in the present study showed crowding in the absence of third molars, and two cases of canine impaction were found.

In the present study, the lower intercanine width was smaller in the prehistoric population of Roaix than in modern Caucasian populations (Table 5). It has been

Table 5 Mean and standard deviations (SD) for mandibular intercanine width of the prehistoric population of Roaix compared with modern populations.

Arch width (mm)	Prehistoric population of Roaix		Modern population					
			(Merz *et al.*, 1991)		(Harper, 1994)		(Vyslozil and Jonke, 1994)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Mandibular canine	24.6	1.9	27.2	2.4	25.4	1.9	27.9	4.1

previously reported that arch widths are always larger in historic or primitive populations than in modern populations (Hunt, 1966; Harper, 1994; Vyslozil and Jonke, 1994; Kasai and Kawamura, 2001). It should be borne in mind that many occlusal traits (crowding) are dependent on jaw development, which is to a greater extent genetically determined (Harris and Johnson, 1991; Mossey, 1999). The crowding and canine impactions observed in the prehistoric population of Roaix seem to be attributable to normal-sized teeth erupting in undersized jaws. Likewise, previous case reports (Iseri and Uzel, 1993; Lukacs, 1998), which respectively described canine impactions and transpositions in prehistoric skulls, support a possible genetic aetiology.

The prehistoric individuals of Roaix were farmers and breeders. The development of agriculture and perhaps conflicts (numerous weapons and arrowheads were found in the skeletal remains of the Roaix population) possibly strengthened the isolation of this community (Courtin, 2000). The probable genetic aetiology of crowding associated with an especially sedentary way of life could explain why all the individuals of the Roaix population presented crowding (Mossey, 1999). Future investigations in prehistoric populations will be necessary to determine whether these findings are isolated to the population of Roaix.

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References

Andrik P 1963 Die Entwicklung der Bißomalien vom Neolithikum bis zur Gegenwart. Fortschritte der Kieferorthopädie 24: 12–21

Brabant H, Twiesselmann F 1969 Etude des dents trouvées dans les cimetières néolithiques de Barmaz I, Barmaz II et Chamblandes. Archives Suisses d'Anthropologie Générale 34: 1–34

Brash J C (ed) 1956 The aetiology of irregularity and malocclusion of the teeth. Dental Board of the United Kingdom, London

Corruccini R S 1984 An epidemiologic transition in dental occlusion in world populations. American Journal of Orthodontics 86: 419–426

Courtin J 2000 Les premiers paysans du Midi. La maison des roches Editor, Paris, pp. 17–35

Davies T G, Pedersen P O 1955 The degree of attrition of the deciduous teeth and first permanent molars of primitive and urbanized Greenland natives. British Dental Journal 99: 35–43

Fastlicht J 1970 Crowding of mandibular incisors. American Journal of Orthodontics 58: 156–163

Ferembach D, Schwydeski I, Stloukal M 1980 Recommendations for age and sex diagnoses of skeletons. Journal of Human Evolution 9: 517–550

Forsberg C M 1988 Tooth size, spacing and crowding in relation to eruption or impaction of third molars. American Journal of Orthodontics and Dentofacial Orthopedics 94: 57–62

Fränkel R, Löffler U 1990 Functional aspects of mandibular crowding. European Journal of Orthodontics 12: 224–229

Harper C 1994 A comparison of medieval and modern dentitions. European Journal of Orthodontics 16: 163–173

Harris E F, Johnson M G 1991 Heritability of craniometric and occlusal variables: a longitudinal sib analysis. American Journal of Orthodontics and Dentofacial Orthopedics 99: 258–268

Helm S, Prydsö U 1979 Prevalence of malocclusion in medieval and modern Danes contrasted. Scandinavian Journal of Dental Research 87: 91–97

Hunt E E 1966 Malocclusion and civilization. American Journal of Physical Anthropology 24: 289–292

Iseri H, Uzel I 1993 Impaction of maxillary canines and congenitally missing third molars. European Journal of Orthodontics 15: 1–5

Kasai K, Kawamura A 2001 Correlation between buccolingual inclination and wear of mandibular teeth in ancient and modern Japanese. Archives of Oral Biology 46: 269–273

Kiliaridis S 1986 The relationship between masticatory function and craniofacial morphology. III. The eruption pattern of the incisors in the growing rat fed a soft diet. European Journal of Orthodontics 8: 71–79

Kiliaridis S, Engström C, Thilander B 1985 The relationship between masticatory function and craniofacial morphology. II. A cephalometric longitudinal analysis in the growing rat fed a soft diet. European Journal of Orthodontics 7: 273–283

Lavelle C L 1973a Alveolar bone loss and tooth attrition in skulls from different population samples. Journal of Periodontal Research 8: 395–399

Lavelle C L 1973b Variation in the secular changes in the teeth and dental arches. Angle Orthodontist 43: 412–421

Little R M 1975 The irregularity index: a quantitative score of mandibular anterior alignment. American Journal of Orthodontics 68: 554–563

Little R M 1999 Stability and relapse of mandibular anterior alignment: University of Washington studies. Seminars in Orthodontics 5: 191–204

Lombardi A V 1982 The adaptive value of dental crowding: a consideration of the biologic basis of malocclusion. American Journal of Orthodontics 81: 38–42

Lukacs J R 1998 Canine transposition in prehistoric Pakistan: Bronze Age and Iron Age case reports. Angle Orthodontist 68: 475–480

Merz M I, Isaacson R J, Germane N, Rubenstein L K 1991 Tooth diameters and arch perimeters in a black and a white population. American Journal of Orthodontics and Dentofacial Orthopedics 100: 53–58

Miles A E W 1963 Dental anthropology. Pergamon Press, Oxford, pp. 191–209

Molnar S 1971 Human tooth wear, tooth function and cultural variability. American Journal of Anthropology 34: 175–190

Mossey P A 1999 The heritability of malocclusion: Part 1—Genetics, principles and terminology. British Journal of Orthodontics 26: 103–113

Pirttiniemi P M, Oikarinen K S, Raustia A M 1994 The effect of removal of all third molars on the dental arches in the third decade of life. Journal of Craniomandibular Practice 12: 23–27

Proffit W R, Fields H W, Moray L J 1998 Prevalence of malocclusion and orthodontic treatment need in the United States. International

Journal of Adult Orthodontics and Orthognathic Surgery 13: 97–106

Sinclair P M, Little R M 1983 Maturation of untreated normal occlusions. American Journal of Orthodontics 83: 231–235

Smyth K C 1934 Some notes on the dentitions of Anglo-Saxon skulls from Bidford-on-Avon with special reference to malocclusion. Dental Record 54: 1–28

Thilander B, Mohlin B, Egermark I 1991 The Carmelite monastery in New Varberg. Proceedings of the Finnish Dental Society 87: 115–125

Van der Linden F P G M 1966 Genetic and environmental factors in dentofacial morphology. American Journal of Orthodontics 52: 576–583

Vyslozil O, Jonke E 1994 Kieferorthopädischanthropometrische Vergleichsuntersuchung an 100 Jahre alten menschlichen Schädeln und österreichische bundesheersoldaten. Informationen aus Orthodontie und Kieferorthopädie 26: 409–436

Weiland F J, Jonke E, Bantleon H P 1997 Secular trends in malocclusion in Austrian men. European Journal of Orthodontics 19: 355–369