Root and canal morphology of the permanent teeth in medieval and current French population

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Title:

Original Article: Root and canal morphology of the permanent teeth in medieval and current French population

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Abstract

Objective

This work describes and compares the root and root canal morphology of a medieval population dating from the 8th-10th century from the southwest of France, and a current French population.

Design

The root morphology of 579 teeth from 70 medieval individuals was analyzed using cone beam computed tomography, and compared with 690 teeth from a current French population of 329 individuals. The Vertucci classification was used to describe the root canal configuration.

Results

In the medieval population, the maxillary first premolar usually had one root. In contrast, in the current population this tooth predominantly had two roots, and the three-root form had appeared. Mandibular canine with two roots was observed in 5.7% of cases, and in the current population this form was found in 1.6% but the difference was not significative. The greatest variability between the two populations in terms of root canal configuration was in one-rooted maxillary first and second premolars, the mandibular canines, and the distal roots of the mandibular first molars. Differences in root numbers and canal configurations of the maxillary molars investigated among the two populations were not significant.

Conclusions

This study indicated that the upper first premolar of the current population tended to have more than one root, while this tooth type of the medieval group mostly appeared with only one. For the root canal configuration, studies in the upper premolars, lower canines and first molars of the current population apparently revealed a significant simplification compared with the ancient group.

Keywords

Root number, Canal morphology, Medieval population, Current population

Abbreviations

CBCT, cone beam computed tomography

Introduction

Teeth are interesting elements to analyze in anthropology. One of the characteristics of teeth is their resistance to physical and chemical aggression. They can give information on the sex, age, eating habits and health of an individual. Dental traits have also been studied by anthropologists and paleontologists to characterize and assess biological relationships and evolutionary trends in hominids and prehistoric humans (Brace et al., 1987). The relative prevalence of specific traits could characterize and differentiate ethnic human groups. European dental morphological traits were characterized by trait absence rather than their presence (Lee & Scott, 2011). These traits are largely under the control of genes, and are minimally affected by environmental factors (Scott & Turner, 1997). They are also genetically conservative, exhibiting minimal modification over many generations. External dental anatomy, enamel thickness and the dentine-enamel junction are extensively studied in paleontology to investigate the relationship between ancient populations. The general evolutionary trend in modern human dentition was found to be toward morphological simplification and a reduction in tooth-size (Pinhasi & Stock, 2011).

In recent years, cone beam computed tomography (CBCT) examinations have been increasingly used to improve the dental diagnosis and therapy. CBCT allows a high-quality three-dimensional reconstruction of root and root canal systems. It is a fast technique, available in many institutions, and is not invasive (Michetti et al., 2010; Monsarrat et al., 2016; Weber et al., 2015). The methods for studying endodontic anatomy can be divided into *ex vivo*, on extracted teeth, and *in vivo* performed directly on patients. This method is considered the most accurate for the analysis of dental anatomy in a large population (Martins et al., 2020).

Root canal configurations are widely studied on current populations, and differences have been observed between geographic origins (Cleghorn et al., 2007; Kottoor et al., 2013; Martins et al., 2018). There are variations in the number of roots, and the etiology of supernumerary roots is unknown; an in-growth of tissue from Hertwig's epithelial root sheath has been claimed as a possible cause (Kelly, 1978; Neville et al., 2015). An important factor contributing to the variability of root canal configuration is the age of the individual (Martins et al., 2018). In fact, the physiological apposition of secondary dentin leads to a decrease in the size of the pulp chamber and the canal diameter over a lifetime and can make the root canal configuration more complex (Wolf et al., 2021).

To our knowledge, research related to internal root morphology is uncommon in the field of anthropology. One of the main reasons is the small archaeological sample that is available and properly preserved for the use of researchers. Knowledge of this anatomical diversity could allow a better understanding of inter-individual variability. Recent studies have investigated the presence of the C-shaped canal in mandibular molars and the root canal morphology of maxillary molars in a prehistoric Chinese population (Ren et al., 2020; Ren et al., 2021). A study conducted on two archaeological populations from the city of Radon in Poland dating from 14th-17th century, and the 18th-19th century, was carried out in 2020 (Przesmycka et al., 2020). In France, excavations are carried out every year, leading to the discovery of ancient cemeteries. The medieval collection studied in this article is the first bioarcheological material from France analyzed regarding root canal morphology.

The purpose of this work was to describe and compare the root and root canal morphology of a medieval population dating from the 8th-10th century from the southwest of France, and a current French population.

Materials and methods

Our protocol was inspired by the checklist proposed by PROUD2020 (Ahmed & Rossi-Fedele, 2020).

Ancient population:

A medieval cemetery was found during the 2019 excavation of the commune of Saint Thibery (department of Herault, Occitanie, southwest of France). Saint Thibery is located about 45 km from Montpellier (Figure 1), and has an ancient history. The oldest traces date back to the Neolithic period (about 4000 years BC), and an agricultural settlement was later found dating back to the ancient Rome period (end of the first century BC), and still active in the early Middle Ages (sixth century). A residence called Villam Nataliam existed in the eighth century. The historical data were more substantiated from the tenth century. According to carbon-14 dating, this cemetery was in active use from the eighth to the tenth century (17 dates, Poznan Radiocarbon Laboratory).

The excavations revealed 165 individuals. This collection was conserved by the National Institute of Preventive Archeological Research (INRAP, Toulouse France). Preliminary studies were conducted on the bones to estimate the age at death and the sex of individuals. For immature individuals, age was estimated through the processes of bone or dental growth and maturation. The stages of tooth maturation defined by Moorrees (1963) and those proposed by Ubelaker (1987) were thus used for children from post-natal to 14 years of age (Moorrees et al., 1963; Fazekas & Kosa, 1978; Ubelaker, 1987). The diaphyseal lengths described by Stloukal and Hanáková (1987) were also used. For adolescents (ages 15-19), the stages of bone maturation described by Birkner (1980) were used by observing the fusion of secondary ossification points at their primary centers. Bone maturation criteria and degenerative traits were used for adults, such as fusions of the iliac crest or the medial end of the clavicle (Lovejoy, 1985; Martins et al., 2012; Webb & Suchey, 1985). Sex determination was carried out on coxal bones according to two approaches. The primary diagnosis was performed according to the probabilistic sex diagnosis method based on metric criteria (Murail et al., 2005). When sex could not be determined, or when measurements could not be taken, a second method was used based on morphological characters (Brůžek, 2002). Where there was discordance between the two methods, or within laterality, the subject was defined as non-determinate. Only individuals with mandible and maxillary fragments were included in this study. Some of the bone pieces were well preserved, as shown in Figure 2a, while others were fragmented, and a preliminary tooth recognition step was necessary (Figure 2b).

Seventy individuals were analyzed in all. The distribution of individuals according to age and gender is presented in Table 1. Only well-preserved permanent teeth were chosen for analysis. The selection criteria were mature roots, no fractures, and no root resorption. Exclusion criteria were complete toothlessness, dental immaturity, root fractures, anatomical peculiarities, and post-mortem deterioration. The teeth of medieval populations have been well described as characterized by abrasions and dental wear (Esclassan et al., 2009). This wear can affect the pulp chamber and consequently the root canal configurations through the apposition of reactional dentine (Gani et al., 2014). Teeth with highly advanced dental wear were excluded from our study. Mandible and maxillary fragments and isolated teeth were scanned using CBCT (Carestream Dental CS9600). The same device was used for the modern population. The acquisition parameters were: 90kV, 3.2mA, field of view 120 x 100mm, and voxel size 0.15mm with dose area product 1089mGy/cm^2. The data obtained was exported in DICOM format. Each individual required one to three scans to record all dental data.

Current population:

CBCT examinations performed in the Odontology Department of Toulouse University Hospital were used to establish the contemporary sample. The city of Toulouse is the fourth most populated city in France, and the hospital received patients from all over the Occitanie region.

The database was spread between January 2019 and July 2021, and the population is composed of patients requiring 3D radiography for endodontic, implant, surgery, or orthodontic treatment. The selection criteria were mature roots, non-carious, no fracture, no root resorption and no root canal filling. The criteria for exclusion were unclear or distorted CBCT images, previously endodontically initiated or treated teeth and teeth with posts or crowns. Any physiological or pathological process such as an immature apex was also excluded. The scanning device used was a Carestream Dental CS9600. Only the voxel size of 0.075mm or 0.150mm and small (60x60mm) or medium (120x100mm) field of view were used. The following parameters were used in the small field of view for an adult of average weight: 120kV, 3.2mA, voxel size 0.075mm and dose area product 454mGy/cm^2. For the medium field of view, the following parameters were used: 120kV, 3.2mA, voxel size 0.150 mm and dose area product 1089mGy/cm^2. Images were exported in DICOM format. All reviews were anonymized using DicomCleaner® software (version 10.2, www.dclunie.com), however, the date of birth, sex of the individual and acquisition parameters were kept.

Finally, 329 individuals were selected (143 men and 186 women), aged between 10 and 81 (average age 40.4 years old SD 17.31 years old). The average age of the men was 40.94 years (minimal age 10 years old, maximal age 81 years old and SD 17.67 years old). The average age of the women was 39.3 years (minimal age 10 years old, maximal age 79 years old and SD 16.8 years old). The distribution of individuals according to age and gender is presented in Table 1.

The teeth analyzed were first and second maxillary premolars, first and second maxillary molars, mandibular canines and first mandibular molars. A total of 579 teeth were analyzed for the ancient population and 690 teeth for the modern population. Detailed descriptions of the dental samples analyzed are available in Table 2.

CBCT image analysis

Images were examined using the CS Dental Imaging® software 3D Module version 3.10.4. All samples (ancient and current populations) were observed in three planes: coronal, sagittal and axial (Figure 3). The following features were analyzed: type and number of tooth, number of roots, number of root canals and canal configuration. We assume a separate root has one-quarter to one-third of the total root length, independent of the others (Turner et al., 1991). An individual root canal was defined as a separate orifice found from the floor of the pulp chamber to apex (Nosrat et al., 2015). The Vertucci classification was chosen in order to record the root canal configuration (Table 3) (Vertucci, 1984).

Statistical analysis:

To ensure the reliability and reproducibility of the results, inter- and intraobserver reliabilities were measured by identifying the root canal anatomy of 50 randomly selected teeth in the ancient population and 50 in the current population. The same images were evaluated after two weeks for intraobserver reliability. Both inter- and intra-examiner reliability were calculated using Cohen's Kappa coefficient.

Chi-2 and Fisher's exact tests were used to compare the two study populations with a level of significance established at 0.05. Statistical analysis was performed using R version 4.0.3 software (The R Project for Statistical Computing; http://www.r-project.org/).

Results

Reliability:

A Cohen kappa coefficient of 0.9 was calculated for intra-observer reliability for the ancient population. The coefficient was 0.85 for the current population. A second reviewer analyzed the same teeth to assess inter-observer reliability, and a coefficient of 0.85 was obtained for ancient population and 0.81 for current population. A coefficient greater than 0.70 was desirable to validate the reproducibility of a study.

Root number and root canal configuration:

The distributions of the number of roots and root canal configurations can be found in the Tables 4, 5 and 6. Table 7 summarizes the elements of interest in our study.

The majority of *maxillary first premolars* that belonged to the ancient population had one root (75.2%). Also in ancient population, two-rooted premolars represented 24.8% and no three-rooted premolar was observed. In the current population, 53.8% had one root but 41% had two root and 5.2% had three roots. The presence of three roots was significant (p=0.029). The number of canals ranged from one to two per root. In the ancient population, the main one-rooted teeth canal configuration was 2-2 (35.4%). Similarly, in the current population, the main configuration was 2-2 (53.7%). The 2-1-2 type was significantly higher in the ancient population (p=0.027).

Ninety-seven percent of *maxillary second premolars* in the ancient population had one root and 3% had two roots. For the current population, 93.5% had one root, 5% had two roots and 1.4% had three roots. The number of canals ranged from one to three in ten variants. In the ancient population, the main one-rooted teeth canal configurations were 2-1 (35.7%) and 1-1 (19.2%). Conversely, in the current population, the most frequent configurations were 1-1 (47.7%) and 2-1 (16.9%). The 1-1 type was significantly higher in the current population (p<0.001) and Type 2-1 was significantly higher in the ancient population (p=0.017). In the ancient population, 94.3% of the *mandibular canines* had one root and 5.7% had two roots. In the current population, 98.4% had one root and only 1.6% had two roots. The main one-rooted configuration was Type 1-1 (ancient population: 74.1% and current population: 91.3%). The configuration was more differentiated in the ancient population, and Type 1-2-1 was found in 19.8%, but was less observed (6.3%) in the current population. This difference was significant (p=0.007).

In the ancient population, 97.8% of *mandibular first molars* had two roots, and only 2.2% had three roots. In the current population, two rooted molars were dominant, but 5.4% of molars had three roots and 2.2% had one root. The distal roots of the two-rooted first mandibular molars were more differentiated in the ancient population. The Type 1-1 configuration predominated (60.7%) over the Type 2-1 configuration (20.2%). In the current population, the major configuration was Type 1-1, followed by Type 1-2-1 (12.9%). Type 2-1 represented only 5.9% of canals. This difference was significant (p=0.015).

The results of the maxillary molars were not significant. In the ancient population, 95% *maxillary first molars* had two roots. In the current population, the percentage was similar (94.9%). In the two populations, the mesial roots of the three-rooted molars were the most variable. The Type 2-1 configuration in the ancient population

(42.1%) and in the current population (52.7%). In the two population, the *maxillary second molars* were diverse in terms of the number of roots. The three-rooted molars were dominant (ancient population: 69.3% and current population: 67.5%) and the Type 1-1 configuration predominated in the mesio-buccal root in the two populations (ancient population: 40.4% and current population: 48.1%).

Discussion

Differences in the number of roots and morphology of root canals were assessed to analyze the morphological variability of the teeth in two samples separated by more than 1000 years

To our knowledge, the medieval French sample is the first bioarcheological material from France analyzed in the context of historical tooth root canal system morphology. The sample comprised 70 individuals (more than other ancient samples).

The number of roots was slightly different between the ancient and current populations. In the medieval population, the predominant form of maxillary first premolars was a single root (75.2%), the two rooted form comprised 24.8% and no three-rooted teeth were observed. In contrast, the proportion of two roots (41%) increased in the current population, with only 53.8% having one root, and the three-root form appearing. The maxillary first premolar generally had two roots within the modern population (Abella et al., 2015; Ahmad & Alenezi, 2016; Saber et al., 2019). In a Spanish population study, 430 first premolars were analyzed, of which 46% were the one-rooted form, 51.4% the two-rooted form, and 2.6% the three-rooted form (Bürklein et al., 2017). The prevalence of the three-root form ranged from 0.5% to 6% in modern populations (Bürklein et al. 2017; Soares & Leonardo, 2003). The high proportion of the single-root form of maxillary second premolars in our two populations was consistent with current data (Saber et al., 2019; Abella et al., 2015; Bürklein et al., 2017; Martins et al., 2017). The three-rooted mandibular first molars were also an interesting tooth. This supernumerary root can be used by anthropologists to trace the geographical origins and migrations of peoples. The relatively low prevalence of three-rooted forms in our ancient population corresponds with data for Europeans (less than 4%) (Martins et al., 2017; Schäfer et al., 2009). In summary, this trend of an increasing number of roots was observed in the maxillary second premolars, maxillary second molars and mandibular first molars without the difference being significant in our study.

In contrast, the lower canine was the only tooth in our study where the number of roots seemed to decrease over time. Indeed, in the ancient population, 5.7% of the canines were two-rooted where only 1.6% of the teeth from the current population were two-rooted. This trend may be related to population migration. It should be noted that Europeans had the highest frequencies of two-rooted lower canines in the world (5-10%). By way of comparison, the prevalence was 2.4% in North Africa, and in East Asia and North America it was extremely rare (Lee & Scott, 2011; Springs & Marquez-Grant, 2010). For the maxillary first and second molars, in our study the number of roots was preserved between the two populations and was not significant. The three-rooted molars were predominant in ancient and current population. In a modern Caucasian population, 91.1% of the maxillary first molars and 72.9% maxillary second molars had three roots (Martins et al., 2017).

There was also a significant difference in root canal configurations. The precise etiology of accessory root canal formation remains unclear. Factors believed to contribute to canal formation include age, geographic location, sex, and population diversity. The apposition of dentine with age, could complicate this configuration. Our study recorded a variation in the configuration of one-rooted maxillary first and second premolars between the two populations. A division of the canal or formation of a new one was observed in the first premolars. Type 2-2 was significantly more common in the current population. This could be related to the formation of a second vestibular root over time. This 2-2 configuration was also recorded in a Caucasian population where 690 first premolars were analyzed (n=469, 68%) (Martins et al., 2017).

A trend of simplification in canal configuration, or the unification of canals over time was found for the maxillary second premolars. The proportion of single canals in the one-rooted teeth was significantly higher in the current population (ancient population: 19.4%, current population: 47.7%, p-value<0.01). In a study of modern Caucasian populations that analyzed 591 second premolars, 39.4% (n=233) were Type 1-1. The difference was statistically significant (p-value<0.01). Although Type 2-1 was more prevalent in our ancient population (35.7%), this prevalence was not significantly different from the results of Martins et al. (2017). A German study observed a majority of 2-2 configurations (56.3%) in one-rooted second premolars (Bürklein et al., 2017).

The mandibular canine appeared to simplify over time. We observed a decrease in the prevalence of two roots associated with the simplification of root canal configuration in our work. Type 1-1 represented more than 90% of the root canals in one-rooted canines within the current population, and this type was observed at 70% in the ancient population. This prevalence ranged from 78% to 98% in modern populations (Versiani et al., 2013). Concerning the first mandibular molar, Type 2-1 on the distal root was significant inferior in the current population (ancient population: 20,2%, current population:5.9%, p-value=0.015). Our results in the current population were lower but not significantly, compared with a study of modern Caucasian populations which analyzed 437 mandibular first molars (n=54, 12.4%, p-value=0.08) (Martins et al., 2017). The maxillary first and second molars appeared to be preserved over the time. The mesio-buccal root was the most variable in the three-rooted molars. Concerning the maxillary first molars, the Type 2-1 configuration was predominant in the two populations (ancient population: 42.1% and current population: 52.7%). This type 2-1 was also predominant in a modern Caucasian population (44.1%) (Martins et al., 2017). Concerning the maxillary second molars, the Type 1-1 configuration was predominant in the two populations (ancient population: 40.8% and current population: 48.1%). Similarly, this Type 1-1 was predominant in a modern Caucasian population (56.2%) (Martins et al., 2017).

Internal dental anatomy is poorly studied for short periods on the human evolutionary scale, as it is the case in our study, but root canal morphologies have a genetic influence and ethnic variations may occur. A study comparing the anatomy of maxillary molars between a Neolithic and a modern Chinese population concluded that there was a trend towards increasing tooth size, however the maxillary molar root and canal morphology remained largely unchanged in 5000 years (Ren et al., 2021). The same authors analyzed 68 mandibular molars from individuals from the same Chinese archaeological site, and studied a particular canal root configuration of the mandibular molar, C-shaped root canals. This configuration was found at a high rate among the ancient population (51.47%) (Ren et al., 2020). The Radom population (Poland) study compared root and root canal anatomy in a period of less than 400 years (14th-17th to 18th-19th century). The authors found an increase in the variability of root number and root canal configurations in the recent population. As observed in our study, maxillary first premolars showed the largest diversity in the number of tooth roots. This morphological work was associated with a haplogroup study. Greater haplogroup diversity was found in the recent population, with few haplogroups from outside of Europe (Przesmycka et al., 2020).

In our study, the medieval collection consisted of 70 individuals dated to a limited period of 200 years. This study population was almost certainly peasants. The most worn teeth were excluded from the analysis because the apposition of reactionary dentin could lead to a complexification of the root canal configuration. Nevertheless, most of the teeth in our medieval sample showed light to moderate abrasion, even in young individuals. Three examples of maxillary first molars from our medieval collection with varying degrees of wear are shown in Supplementary data 1. Tooth wear is a continual non-pathological process characterized by enamel and dentine loss due to physical or chemo-physical processes. Tooth wear is not the result of caries, resorption, or trauma. Wear begins as soon as a tooth erupts. It's the consequence of the tooth's contact with other teeth (dental attrition), with objects other than teeth (dental abrasion) or exposure to acids not derived from oral bacteria (dental erosion) (Schlueter et al., 2020). Dental wear increases with age (Jilkova et al., 2019). This dental abrasion was characteristic of medieval teeth. Wear was intense, rapid and generalized. It was linked to lifestyle and dietary habits and increased with age. Food certainly contained many abrasive elements like vegetables, cereals and bread (Boldsen, 2005; Esclassan et al., 2009; Esclassan et al., 2015; Richter & Eliasson, 2016). This wear may have tended to increase the variability of the canal. Processes of adaptation and dietary changes led to the evolution of the dental system (Moreno-Gomez, 2013).

CBCT was used in the present study because it permitted complete crania and mandibles to be analyzed. Archeological samples receive a lower radiation than in a conventional scanner, and the CBCT does not damage historical material. A database of patients was available from the same device that enabled the ancient population acquisitions.

Some limitations to this study should be noted. The choice of two voxel sizes (0.075 and 0.15 mm) for the current population might be questioned, but no significant difference was found for the root canal configurations between these two resolutions. In other words, the 0.075 mm voxel size did not reveal a more accurate configuration than the 0.15 mm resolution in our study. A systematic review of the literature was conducted in 2020 with the objective of evaluating the relationship between voxel size and prevalence of the second mesio-buccal canal in maxillary molars. The authors included publications with a voxel size equal to or less than 0.2 mm. They concluded that there was no significant association between voxel size and second mesio-buccal canal visualization (Martins et al., 2020). Another bias could be the difference in quality between *in vivo* acquisition for current population and *ex vivo* for the ancient population. Acquisition for the current population may have led to some biases in the readings due to artifacts (tissues, fillings etc.). This may have affected the visualizations of the root canal configurations. All CBCTs that were blurred or had significant metallic artifacts were excluded. Teeth with a root canal configuration that could not be used were also omitted from our work. An *in vivo* analysis was preferred for the current populations because it allowed the study of a larger sample size while preserving the age and sex of individuals.

The Cohen kappa coefficient calculated in our study was slightly higher for the ancient population for both intra- and interobserver reliability, than for the current population. This better coefficient result could be related to the absence of artefacts on the CBCTs of the ancient population due to the absence of surrounding soft tissue and patient movements. Finally, only 70 medieval individuals could be analyzed in our study. Bone pieces from archaeological collections are often worn or damaged, and the lack of information (age or gender) for some individuals makes the analysis more complex. The size of the sample means that care must be taken with the results obtained, and with their interpretation.

Conclusion

This CBCT study showed an increase in variability in the number of roots by comparing the teeth of two populations from different periods. The upper first premolar of the current population tended to have more than one root, while this tooth type of the medieval group mostly appeared with only one. The canal configuration, however, tends to simplify with evolution. A significant simplification of the root canal structure was found in the upper premolars, lower canines and first molars of the current population. Differences in root numbers and canal configurations of the maxillary molars investigated among the two populations were not significant. Given the small sample size and the few studies, this observed trend would need to be confirmed with further work. It would be interesting to conduct these same analyses on other ancient populations. Has dental anatomy changed over short periods during human evolution?

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Figure captions

Figure 1: Location map of the commune of Saint Thibery in the department of Hérault (Occitanie region)

Figure 2: In 2a, photograph of a relatively well-preserved maxilla from a male individual estimated to be between 30 and 35 years old. Identification: SP1001. In 2b, photograph of a fragmented maxilla from a female individual estimated to be between 25 and 29 years old. Identification: SP1006

Figure 3: Example of a coronal (a), sagittal (b) and axial (c) section of a right maxillary second premolar.

Tables

Table 1: Distribution of medieval and current individuals according to age and gender

Table 2: Detailed descriptions of the dental samples

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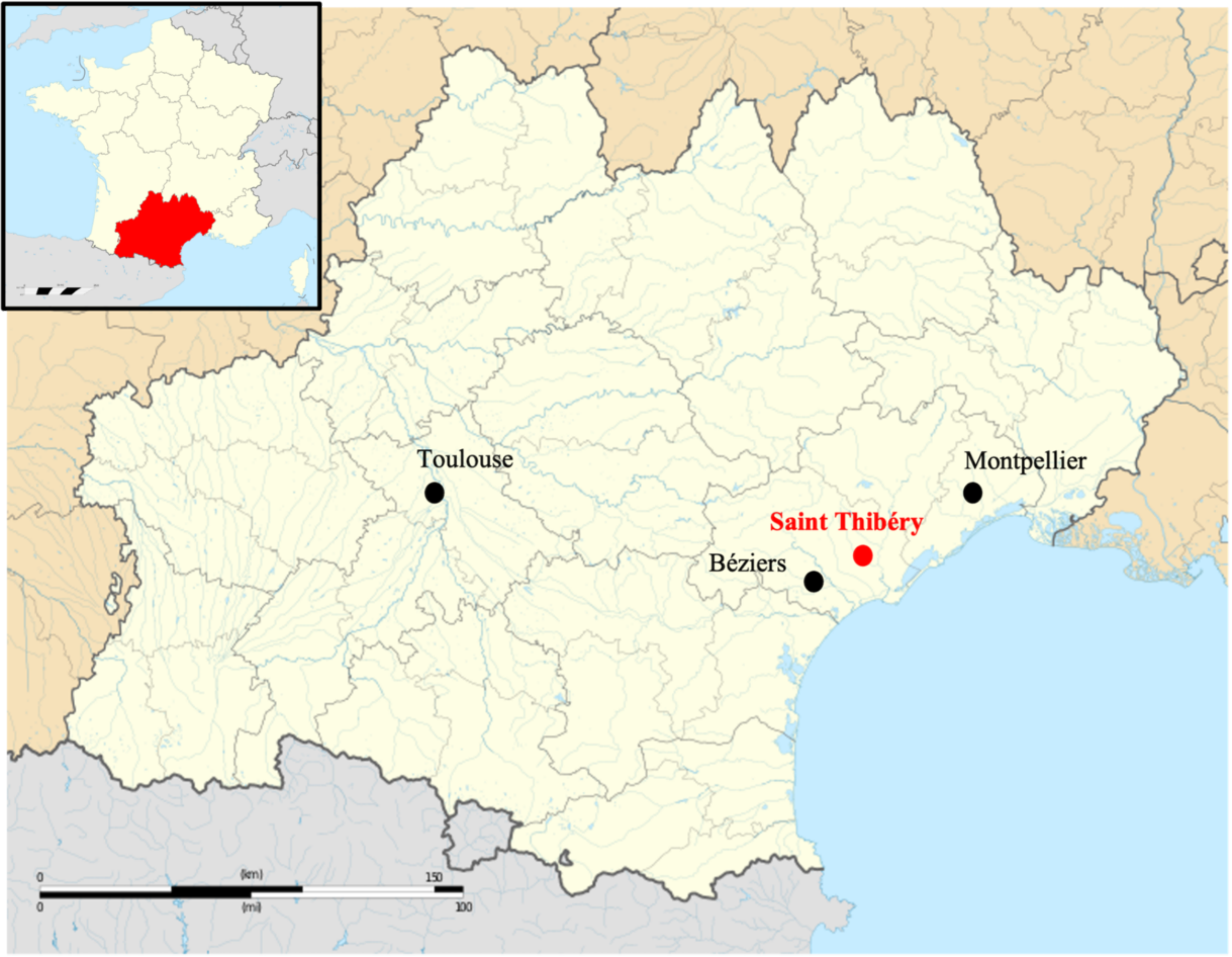
Table 5: Detailed description and comparison of the root and canal anatomy of the maxillary first and second molars between the ancient population and current population.

Table 6: Detailed description and comparison of the root and canal anatomy of the mandibular canines and first molars between the ancient population and current population

Table 7: Comparison of root and root canal morphology between the ancient population and the current population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Montpellier
Saint Thibéry
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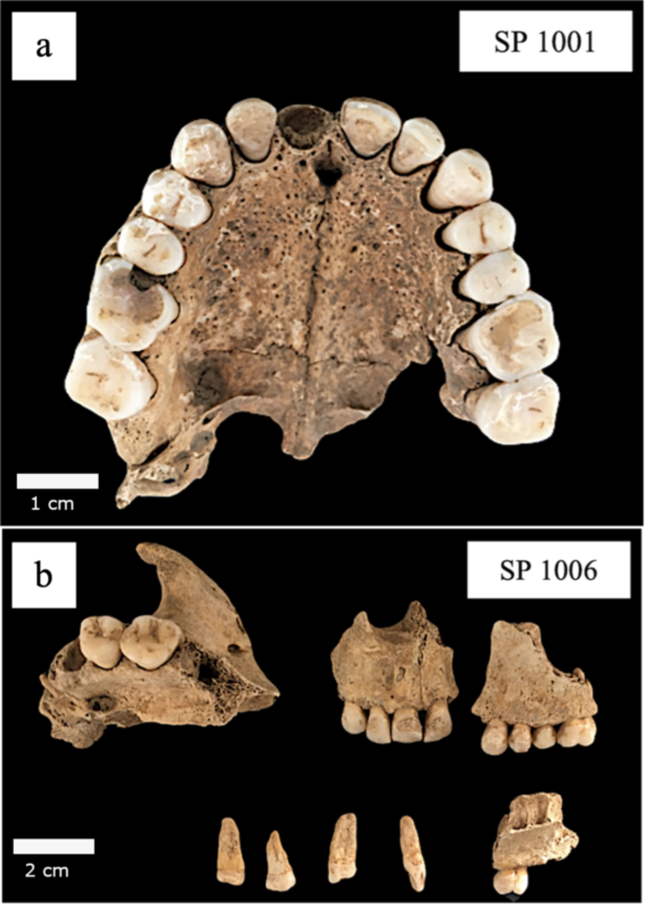
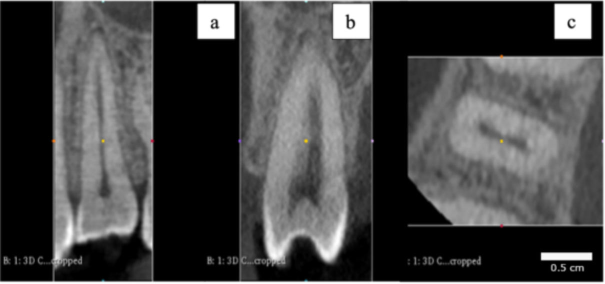


a
SP 1001
1 cm
b
SP 1006
2 cm



a
b
c
B: 1: 3D C...cropped
B: 1: 3D C...cropped
: 1: 3D C...cropped
0.5 cm

Table 1: Distribution of medieval and current individuals according to age and gender

	Gender	Age (years old)		
		< 40	≥ 40	Non-determinate
Ancient population	Male	17	16	1
	Female	14	15	
	Non-determinate	6	1	
Current population	Male	73	70	
	Female	96	90	

Table 2: Detailed descriptions of the dental samples

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No Teeth	Total		Female		Male		Non-determinate
	Ancient population	Current population	Ancient population	Current population	Ancient population	Current population	Ancient population
14/24	109	173	45	98	54	75	10
15/25	101	139	37	81	55	58	9
16/26	80	78	28	43	43	35	9
17/27	75	80	30	39	37	41	8
33/43	123	128	52	70	63	58	8
36/46	91	92	36	47	43	45	12
Total	*579*	*690*	*228*	*378*	*295*	*312*	*56*

Table 3: Definition of Vertucci's classification and illustrations of root canal configurations from the teeth analysed in this study.

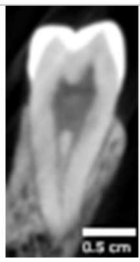
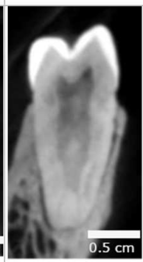
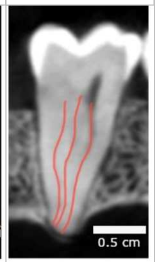
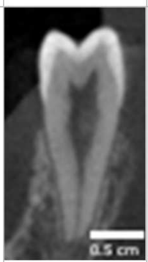
Classification of Vertucci	Type I	Type II	Type III	Type IV	Type V	Type VI	Type VII	Type VIII
Definition	1-1	2-1	1-2-1	2-2	1-2	2-1-2	1-2-1-2	3-3
Root canal configuration								
'Examples from ancient population								
Examples from current population								

Table 4: Detailed description and comparison of the root and canal anatomy of the maxillary first and second premolars between the ancient population and current population.

No teeth	No roots	Type of canal	Population	Number of roots	1-1	2-1	1-2-1	2-2	1-2	2-1-2	1-2-1-2	3-3	Others
14/24	1	Single	Ancient	82	11 (13.4%)	20 (24.4%)	2 (2.4%)	29 (35.4%) *	7 (8.5%)	11 (13.4%)*	-	-	2 (2.4%)
			Current	93	8 (8.6%)	24 (25.8%)	4 (4.3%)	49 (53.7%) *	5 (5,4%)	3 (3.2%)*	-	-	-
	2	Buccal	Ancient	27	24 (88.9%)	-	-	2 (7,4%)	1 (3.7%)	-	-	-	-
			Current	71	66 (93%)	-	-	1 (1.4%)	4 (5.6%)	-	-	-	-
		Palatine	Ancient	27	27 (100%)	-	-	-	-	-	-	-	-
			Current	71	70 (98.6%)	-	-	-	1 (1.4%)	-	-	-	-
	3	Mesiobuccal	Ancient	-	-	-	-	-	-	-	-	-	-
			Current	9	9 (100%)	-	-	-	-	-	-	-	-
		Distobuccal	Ancient	-	-	-	-	-	-	-	-	-	-
			Current	9	9 (100%)	-	-	-	-	-	-	-	-
		Palatine	Ancient	-	-	-	-	-	-	-	-	-	-
			Current	9	9 (100%)	-	-	-	-	-	-	-	-
15/25	1	Single	Ancient	98	19 (19.4%)***	35 (35.7%)***	12 (12.2%)	13 (13.3%)	9 (9.2%)	5 (5.1%)	2 (2%)	-	3 (2.94%)
			Current	130	62 (47.7%)***	22 (16.9%)***	17 (13,1%)	16 (12.3%)	7 (5.4%)	4 (3.1%)	1 (0.8%)	1 (0.8%)	-
	2	Buccal	Ancient	3	3 (100%)	-	-	-	-	-	-	-	-
			Current	7	6 (85,7%)	-	-	-	-	-	-	-	-
		Palatine	Ancient	3	3 (100%)	-	-	-	-	-	-	-	-
			Current	7	7 (100%)	-	-	-	-	-	-	-	-
	3	Mesiobuccal	Ancient	-	-	-	-	-	-	-	-	-	-
			Current	2	2 (100%)	-	-	-	-	-	-	-	-
		Distobuccal	Ancient	-	-	-	-	-	-	-	-	-	-
			Current	2	2 (100%)	-	-	-	-	-	-	-	-
		Palatine	Ancient	-	-	-	-	-	-	-	-	-	-
			Current	2	2 (100%)	-	-	-	-	-	-	-	-

*Level of significiance: *Pvalue≤ 0.05, **Pvalue≤0.01, ***Pvalue≤0.001*

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Table 5: Detailed description and comparison of the root and canal anatomy of the maxillary first and second molars between the ancient population and current population.

No teeth	No roots	Type of canal	Population	Number of roots	1-1	2-1	1-2-1	2-2	1-2	2-1-2	3-3	Others
16/26	2	Mesiobuccal	Ancient	4	-	2 (50%)	-	-	-	2 (50%)	-	-
			Current	4	-	2 (50%)	-	2 (50%)	-	-	-	-
		Distobuccal + Palatine	Ancient	4	-	-	-	4 (100%)	-	-	-	-
			Current	4	-	-	-	4 (100%)	-	-	-	-
	3	Mesiobuccal	Ancient	76	12 (15.8%)	32 (42.1%)	2 (2.6%)	15 (19.7%)	2 (2.6%)	7 (9.2%)	-	6 (7.9%)
			Current	74	20 (27.8%)	39 (52.7%)	-	12 (16.2%)	2 (2.7%)	1 (1.4%)	-	-
		Distobuccal	Ancient	76	76 (100%)	-	-	-	-	-	-	-
			Current	74	71 (95.9%)	-	1 (1.4%)	-	2 (2.7%)	-	-	-
		Palatine	Ancient	76	72 (94.7%)	2 (2.6%)	1 (1.3%)	-	1 (1.3%)	-	-	-
			Current	74	69 (93.2%)	1 (1.4%)	3 (4.1%)	-	1 (1.4%)	-	-	-
17/27	1	Single	Ancient	13	-	4 (30.8%)	-	2 (15.4%)	1 (7.7%)	1 (7.7%)	1 (7.7%)	4 (30.8%)
			Current	7	-	1 (14.3%)	-	-	-	-	4 (57.1%)	2 (28.6%)
	2	Mesiobuccal	Ancient	10	9 (90%)	-	1 (10%)	-	-	-	-	-
			Current	19	14 (73.7%)	2 (10.5%)	-	3 (15.8%)	-	-	-	-
		Distobuccal + Palatine	Ancient	10	-	-	-	10 (100%)	-	-	-	-
			Current	19			-	19 (100%)	-	-	-	-
	3	Mesiobuccal	Ancient	52	21 (40.4%)	12 (23.1%)	3 (5.8%)	9 (17.3%)	5 (9.6%)	1 (1.9%)	-	1 (1.9%)
			Current	54	26 (48.1%)	15 (27.8%)	2 (3.7%)	4 (7.4%)	4 (7.4%)	3 (5.6%)	-	-
		Distobuccal	Ancient	52	52 (100%)	-	-	-	-	-	-	-
			Current	54	52 (96.3%)	-	-	-	2 (3.7%)	-	-	-
		Palatine	Ancient	52	52 (100%)	-	-	-	-	-	-	-
			Current	54	54 (100%)	-	-	-	-	-	-	-

Numeration according to Fédération Dentaire Internationale

Table 6: Detailed description and comparison of the root and canal anatomy of the mandibular canines and first molars between the ancient population and current population

No teeth	No roots	Type of canal	Population	Number of roots	1-1	2-1	1-2-1	2-2	1-2	2-1-2	1-2-1-2	Others
33/43	1	Single	Ancient	116	86 (74.1%)***	-	23 (19.8%)**	3 (2.6%)	2 (1.7%)	-	1 (0.9%)	1 (0.9%)
			Current	126	115 (91.3%)***	-	8 (6.3%)**	-	3 (2.4%)	-	-	-
	2	Buccal	Ancient	7	7 (100%)	-	-	-	-	-	-	-
			Current	2	2 (100%)	-	-	-	-	-	-	-
		Lingual	Ancient	7	7 (100%)	-	-	-	-	-	-	-
			Current	2	2 (100%)	-	-	-	-	-	-	-
36/46	1	Single	Ancient	-	-	-	-	-	-	-	-	-
			Current	2	-	-	-	-	-	-	-	2 (100%)
	2	Mesial	Ancient	89	1 (1.1%)	43 (48.3%)	1 (1.1%)	31 (34.8%)	-	6 (6.7%)	-	7 (7.9%)
			Current	85	-	39 (45.9%)	-	45 (52.9%)	-	1 (1.2%)	-	-
		Distobuccal	Ancient	89	54 (60.7%)	18 (20.2)*	6 (6.7%)	1 (1.1%)	4 (4,5%)	1 (1.1%)	2 (2.2%)	3 (3.4%)
			Current	85	59 (69.4%)	5 (5.9)*	11 (12.9%)	4 (4.7%)	6 (7,1%)	-	-	-
	3	Mesial	Ancient	2	-	-	-	2 (100%)	-	-	-	-
			Current	5	-	4 (80%)	-	1 (20%)	-	-	-	-
		Disto-buccal	Ancient	2	2 (100%)	-	-	-	-	-	-	-
			Current	5	5 (100%)	-	-	-	-	-	-	-
		Disto-lingual	Ancient	2	2 (100%)	-	-	-	-	-	-	-
			Current	5	5 (100%)	-	-	-	-	-	-	-

*Level of significiance: *Pvalue≤ 0.05, **Pvalue≤0.01, ***Pvalue≤0.001*

Numeration according to Fédération Dentaire Internationale

Table 7: Comparison of root and root canal morphology between the ancient population and the current population

No teeth	No roots	Percentage of roots (%)		Root canal configuration (%)				Evolutionary trend
		Ancient population	Current population	Type (Vertucci)		Ancient population	Current population	
14/24	1	75.2***	53.8***		*2-2*	35.4*	53.7*	Increase in root number Decrease in root canal variability Root canal simplification
					2-1	24.4	25.8	
					2-1-2	13.4*	3.2*	
	2	24.8**	41**					
	3	0*	5.2*					
15/25	1	97	93.5		*1-1*	19.4***	47.7***	Tendancy in increase in root number Root canal simplification
					2-1	35.7***	16.9***	
	2	3	5					
	3	0	1.4					
16/26	2	5	5.1					Tendency to preserve the number of roots and root canal configuration
	3	95	94 .9	*Root Mesio-buccal*	*1-1*	15.8	27.8	
					2-1	42.1	52.7	
					2-2	19.7	16.2	
17/27	1	17.3	8.7					Tendency to preserve the number of roots and root canal configuration
	2	13.3	23.7	*Root Mesio-buccal*	*1-1*	90	73.7	
	3	69.3	67.5	*Root Mesio-buccal*	*1-1*	40.4	48.1	
					2-1	23.1	27.8	
					2-2	17.3	7.4	
33/43	1	94.3	98.4		*1-1*	74.1***	91.3***	Tendency to decrease the number of roots Root canal simplification
					1-2-1	19.8**	6.3**	
	2	5.7	1.6					
36/46	1	0	2.2					Tendency in increase variability in root number Decrease in root canal number in the distal root
	2	97.8	92.4	Root Disto-Buccal	*1-1*	60.7	69.4	
					2-1	20.2*	5.9*	
					1-2-1	6.7	12.9	
	3	2.2	5.4					

Note: In this table, only the items of interest have been listed.

*Level of significiance: *Pvalue≤ 0.05, **Pvalue≤0.01, ***Pvalue≤0.001*

Numeration according to Fédération Dentaire Internationale