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Oral tori in a sample of the Spanish university students: prevalence and morphology

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Abstract Oral *tori* are an enlargement of the osseous tissue in different parts of the upper and lower maxillaries. Oral *tori* were studied in a Spanish sample of 278 university students, from both sexes, and age between 18 and 39 years. Presence or absence and morphological variability (analysis of their location, degree of development, form, and symmetry) of the oral *tori* were the topics of this research. A high prevalence with no sexual dimorphism was found for the three oral *tori* in the Spanish student population (*torus palatinus* 44.3%, *torus maxillaris* 50.7%, *torus mandibularis* 54.7%). Only 20.3% of the individuals had all the three *tori*. The *torus palatinus* was well developed in 52.9% of the individuals; it had a non-lobular form, and its more frequent location was in the middle or middle-posterior palate. The *torus maxillaris* was symmetric with respect to both sides of the maxilla, and asymmetric with respect to the buccal and lingual surfaces on the same side. All showed simple form on the buccal surface, and multiple on the lingual one. The location was middle-posterior on the buccal surface, and posterior on the lingual one. The *torus mandibularis* was symmetric, and had the greater degree of expression. In all the cases, the location was middle, and the most frequent form was multiple. The analysis of the world distribution of the prevalence leads us to reject the traditional notion that the oral *tori* occur with more frequency in populations from the Arctic and Sub-arctic regions, and to support the idea of the genetic origin as the main factor for the etiology of these *tori*.

Key word *Torus palatinus*; *torus mandibularis*; *torus maxillaris*; Spanish population.

Resumo Os *tori* orais são espessamentos do tecido ósseo que ocorre em diferentes partes do maxilar e da mandíbula. Estes caracteres discretos foram estudados em 278 estudantes universitários espanhóis, de ambos os sexos, com idades compreendidas entre os 18 e os 39 anos. Os tópicos da investigação foram o estudo da sua presença ou ausência e da variabilidade morfológica (análise da localização, do grau de desenvolvimento, da forma e da simetria). Na amostra não foi encon-

trado dimorfismo sexual nos três *tori* orais estudados (*torus palatinus* 44.3%, *torus maxillaris* 50.7%, *torus mandibularis* 54.7%). Somente 20,3% dos indivíduos apresentavam todos os *tori*. O *torus palatinus* encontrava-se bem desenvolvido em 52,9% dos indivíduos e tinha uma forma não lobular, sendo mais frequente na parte média ou na média-posterior do palato. O *torus maxillaris* era simétrico no maxilar e assimétrico nas superfícies bucal e lingual do mesmo lado. Todos mostraram uma forma simples na superfície bucal e múltipla na lingual. A sua localização era média-posterior na superfície bucal e posterior na lingual. Quanto ao *torus mandibularis* apresentava-se simétrico e com elevado grau de desenvolvimento. Em todos os casos tinha localização medial e a forma múltipla era a mais frequente. A análise da distribuição mundial relativamente à sua prevalência leva-nos a rejeitar a hipótese tradicional de que os *tori* orais ocorrem com maior frequência nas populações das regiões árticas e subárticas mas corroboram a hipótese de uma origem genética como factor mais importante para a sua etiologia.

Palavras-chave *Torus palatinus*; *torus mandibularis*; *torus maxillaris*; população espanhola.

Introduction

Oral *tori* are an enlargement of the osseous tissue in different parts of the upper and lower maxillaries (Hauser and De Stefano, 1989). These traits have been described with different names, such as osteomas, exostoses, hyperostoses, hyperplastic bone, or *tori*. The term *torus*, *tori* in plural, is the most used in the current literature because it is not directly associated with etiology.

The *torus palatinus* (TP), the *torus mandibularis* (TM), and the *torus maxillaris* (TMx) are studied in the present article. The term TP (Dorrance, 1929) is a paramedian, rarely median, bony protuberance of varying size, form and extent, which is situated along the median suture of the hard palate (Hauser and De Stefano, 1989). The term TM (Fürst, 1908) refers to a bony protuberance of varying size, shape and extent on the lingual surface of the mandible below its free alveolar margin (Hauser and De Stefano, 1989). The term TMx (Kajava, 1912) refers to either irregular bony nodules of varying sizes or a mound-like thickening of the alveolar process on the buccal and lingual sides (Hauser and De Stefano, 1989).

It has been postulated that the etiology of the *tori* consists of interplay of multi-factorial genetic and environmental factors that determine

their expressiveness (Hauser and De Stefano, 1989; Haugen, 1992; Seah, 1995; Jainkittivon and Langlais, 2000). On the other hand, it is believed that the prevalence of the oral *tori* is higher in populations of an Asiatic origin than in Europeans (King and Moore, 1976; Reichart *et al.*, 1988; Haugen, 1992), but a detailed analysis of the frequencies published for human groups of very diverse chronology, genetic pool and environmental conditions (nutrition, daily activities, etc) offer an accentuated heterogeneity in the results (Galera *et al.*, 1996).

It is important to emphasize that there are numerous reports on oral *tori* of the Iberian Peninsula past populations (Garralda, 1974; Souich, 1980; Vives, 1987; Galera, 1989; Cunha, 1994; Galera *et al.*, 1995; Galera *et al.*, 1996; Garralda *et al.*, 1997; Herrerín, 2000); however, nothing is known about *tori* in Spanish living populations, being the latter kind of studies fundamental to interpret correctly the evolution of the morphological variability of these traits, and to apply them in fields like forensic anthropology.

With the present article we hope to establish the prevalence of oral *tori* in a sample of the current Spanish population, analyzing its morphological variability, sexual dimorphism, and correlation among them. The results will be interpreted and discussed with the results of other populations near in time, and the different theories on the etiology of the *tori*.

Materials and methods

The sample used for the present study was 278 students of Biology (127 males and 151 females) from the Universities of Alcalá de Henares and Complutense of Madrid (Spain). All the individuals were between 18 and 39 years of age, although the majority of them (96.76%) were between 19 and 29 years.

The analysis of the place of birth of the individuals of the sample indicated that the great majority was from the central zone of Spain (92.1% of the individuals were born in the Autonomous Communities of Madrid, Castilla-La Mancha and Castilla-León) but the frequencies obtained for the place of birth of the parents and grandparents, showed that the sample could be considered as representative of Spain. The socioeconomic level was medium to high (Moreno, 2001).

Anthropological methods

In each of the individuals, the TP, the TMx, and the TM were studied. Mandible and upper maxillary casts were obtained with the technique normally used in clinics which is relatively inexpensive and requires the use of alginate, maxillaries stone and maxillaries impressions (Teaford and Oyen, 1989). Moreover, in order to verify the results obtained from the casts, each of the individuals of the sample was subjected to a naked eye observation in which the characters studied in the casts were analyzed.

All the traits were taken two times by one of the authors (J. M. Moreno) and no intra-observer error was observed.

The protocol used in the study was the following:

- Presence or absence of each of the *tori*;
- Morphological variability of the *tori* which includes the analysis of their location, degree of development, form, and symmetry.

Location

In order to analyze the variability of TP, six categories were made:

- Total TP - the *torus* appears along the whole of the middle line of the palate.
- Anterior TP - the *torus* occupies the anterior part and does not go beyond the transverse palatinate folds (*plicae palatinae transversae*).
- Medial or middle TP - the beginning of the *torus* is just behind the transverse palatinate folds and its final part does not reach the posterior zone of the middle line of the palate.
- Anterior - middle TP.
- Posterior TP - the beginning of the *torus* is not just behind the transverse palatine folds, but more behind, and its final part reaches the posterior zone of the middle line of the palate.
- Middle - posterior TP.

The location of the TMx and TM was established according to its position with relation to the dental pieces: anterior (incisive), middle (canine and premolar), middle-posterior (second premolar and molar), and posterior (molar). In the case of the TMx, this location was established both for the internal and external surfaces.

Degree of development

The degree of development for the TP and TM, when present, was measured using two categories, visible, when the *torus* was visible with the naked eye, and palpable, when it was only detected by touch. In the case of the TMx, two categories were considered, week, when one of the surfaces was affected, the buccal or the lingual, and strong, when both surfaces were affected (Hauser and De Stefano, 1989).

Form

The form of the TP was established on the basis of two categories, lobular and non-lobular. The forms of the TM and TMx take into consideration two categories, simple (continuous and homogeneous) and multiple (divided, forming two or more lobes).

Laterality (symmetry)

The symmetry of the TM and TMx was analyzed, for both sides, and for each individual.

Statistical methods

The total frequency and the sex frequencies were established for each of the *tori*, and in each one for their location, degree of development, form, and symmetry.

The χ^2 test with the Yates correction for tables of undefined number of lines and columns was used. The Fisher exact test was also calculated when the number of data of a trait was low (Sokal and Rohlf, 1981).

In order to study the possible association among the *tori*, the frequencies were calculated for the following cases: individuals that had the three *tori*, individuals with TP and TMx, individuals with TP and TM, and individuals with TMx and TM. Besides, the Spearman rank correlation, and the χ^2 test was calculated (Sokal and Rohlf, 1981). Frequencies can be used to evaluate possible associations in ordinal discontinuous data –data which are part of a morphological continuum, but are separated into discrete classes for purposes of analysis.

Results

Palatine *torus*

The prevalence of the TP in the Spanish population sample is high, reaching almost 50% in women (Table 1). Statistically significant sexual dimorphism can not be demonstrated (P = 0.0623, Pearson Chi Square with Yates's correction).

Table 1. Prevalence of the oral tori in a sample of the Spanish population.

Traits		Total		Females		Males	
		N	%	N	%	N	%
Torus palatinus	Absent	155	55.75	76	50.34	79	62.20
	Present	123	44.25	75	49.66	48	37.80
	Total	**278**	**100.00**	**151**	**100.00**	**127**	**100.00**
Torus maxillaris	Absent≠	137	49.28	69	45.70	68	53.54
	Present	141	50.72	82	54.30	59	46.46
	Total	**278**	**100.00**	**151**	**100.00**	**127**	**100.00**

The most frequently morphological location of the TP (Table 2) was the middle-posterior part of the palate (42.28%), and only in 1.62% of the cases was located in the anterior part or all the middle line of the palate. These differences were very statistically significant (P = 0.001, Pearson Chi Square). The sexual differences found were only highly statistically significant (P = 0.0035, Pearson Chi Square) for the case of the posterior TP, and in favor of the women.

Considering the degree of expression of the sample (Table 2), it was seen that the 123 individuals with TP, in 65 (52.85%) the *torus* was visible, that is, more developed, and in 58 (47.15%), palpable. Sexual dimorphism of the expression was observed, in the sense that the males showed a minor expression of the character, which was statistically significant in

the case of the middle-posterior TP (P = 0.0183, Pearson Chi Square with Fisher's test).

As to shape, 100% of the individuals that had TP, this was of the non-lobular type.

Table 2. Location, and degree of expression of the torus palatinus in a sample of the Spanish population.

Location	Degree of expression	Total		Females		Males	
		N	%	N	%	N	%
Anterior	Palpable	1	0.81	0	0.00	1	2.08
	Visible	0	0.00	0	0.00	0	0.00
Middle	Palpable	17	13.82	8	10.67	9	18.75
	Visible	11	8.95	7	9.33	4	8.34
Posterior	Palpable	21	17.07	14	18.67	7	14.58
	Visible	17	13.82	14	18.67	3	6.25
Antero--middle	Palpable	0	0.00	0	0.00	0	0.00
	Visible	3	2.44	1	1.33	2	4.17
Middle--posterior	Palpable	19	15.45	7	9.33	12	25.00
	Visible	33	26.83	24	32.00	9	18.75
Total	Palpable	0	0.00	0	0.00	0	0.00
	Visible	1	0.81	0	0.00	1	2.08

Maxillary *torus*

The prevalence of TMx is high, more than 50% (Table 1). Women had higher frequencies than men, but this difference was not statistically significant (P = 0.2367, Pearson Chi Square with Yate's correction).

The 100% of individuals with TMx had a middle-posterior location (second premolar, and molar region) in their buccal surface, and posterior (molar region) on their lingual surface.

From the 141 of the individuals with *torus*, 112 had it both on the right side as well as on the left side (79.43% of symmetry), against 29 in which only one side is affected (20.57% of asymmetry), being the right side the most frequent (Table 3). Sexual dimorphism was seen for symme-

try in favor of women, which, was not statistically significant (P = 0.0587, Pearson Chi Square). Sexual dimorphism of the asymmetry of the TMx favoring men was found, although this was not statistically significant (P = 0.5774, Pearson Chi Square).

The study of the degree of development (Table 3) showed that in 26.25% of the individuals the *torus* was strong (buccal + lingual), and in 73.75% it was week. The differences with respect to the buccal and lingual surfaces of a same side, showed higher frequencies of individuals that had *torus* only on the buccal surface, followed by individuals in which the lingual and buccal surfaces were affected simultaneously, being, therefore, the lower frequencies for the individuals with *torus* only on the lingual surface. This pattern was true both in individuals with symmetrical as well as asymmetrical *tori*.

The shape of the TMx was simple on its buccal surface and multiple on its lingual one in 100% of the individuals that had it.

Table 3. Laterality and degree of expression of the torus maxillaris in a sample of the Spanish population.

Location	Degree of expression	Total		Females		Males	
		N	%	N	%	N	%
Asymmetry (right)	Buccal	17	12.06	10	12.20	7	11.87
	Lingual	1	0.71	0	0.00	1	1.69
	Buccal + Lingual	5	3.55	4	4.88	1	1.69
Asymmetry (left)	Buccal	6	4.25	2	2.44	4	6.78
	Lingual	0	0.00	0	0.00	0	0.00
	Buccal + Lingual	0	0.00	0	0.00	0	0.00
Symmetry (right + left)	Buccal	56	39.72	32	39.02	24	40.68
	Lingual	22	15.60	14	17.07	8	13.56
	Buccal + Lingual	32	22.70	18	21.95	14	23.73
	Right Buccal + Left Lingual	2	1.41	2	2.44	0	0.00

Mandibular *torus*

The frequencies of the TM shows that more than half of the individuals (54.68%) presented this character, being the most frequent one of the three *tori* studied (Table 1). No statistically significant sexual dimorphism was found (P = 0.6181 Pearson Chi Square with Yates' correction).

In 100% of the individuals with TM, this had a middle location affecting canine and premolar region.

The study of the laterality (Table 4) shows that a high number of individuals, 126 (82.89%), had symmetrical *tori*, that is, it showed on both sides, right and left, of the mandible; while only in 26 individuals (17.11%) it was asymmetrical, that is, only one side was affected, the left side being slightly more frequent. Symmetry by sexes showed not statistically significant differences (P = 0.4760, Pearson Chi Square).

The degree of expression of TM (Table 4) was high, since the individuals with visible *tori* predominate. The *tori* with the maximal expression were found in the 60.52% of the individuals with symmetric and visible *tori*. The less developed *tori* predominated in the individuals with asymmetric and palpable *tori* (10.53%). The degree of expression by sexes gave the same results as the ones obtained for the global sample. It must be noted that, in case of the asymmetric *tori* being present, the

Table 4. Laterality and degree of expression of the torus mandibularis in a sample of the Spanish population.

Location	Degree of expression	Total		Females		Males	
		N	%	N	%	N	%
Asymmetry (right)	Palpable	7	4.61	4	5.00	3	4.17
	Visible	5	3.29	2	2.50	3	4.17
Asymmetry (left)	Palpable	9	5.92	5	6.25	4	5.55
	Visible	5	3.29	2	2.50	3	4.17
Symmetry (right + left)	Palpable	23	15.13	9	11.25	14	19.44
	Visible	92	60.52	49	61.25	43	59.72
	Right Palpable + Left Visible	4	2.63	3	3.75	1	1.39
	Right Visible + Left Palpable	7	4.61	6	7.50	1	1.39

sexual dimorphism was not statistically significant (P = 1, Pearson Chi Square). On Table 4 it can also be seen that there was a series of individuals (7.24%) that showed a symmetric *torus* which did not appear equally developed on both sides of the mandible, that is, while on the one side it was palpable, on the other it was visible, a situation which occurred more frequently in women than in men.

Of all the individuals that showed TM, in 99 (65.13%), the *torus* had a multiple shape, and in 53 (34.87%), a simple one.

Association among the *tori*

The frequencies of the association among the *tori* showed that from the total of 232 individuals that had one or various *tori*, in 95 of them (40.95%) there was no association, that is, these individuals only had one of the three - 40 with TM (17.24%), 28 with TMx (12.07%), and 27 with TP (11.64%). In 137 individuals (59.05%) there was at least association of two *tori*. In the association cases, the highest frequencies were for the individuals with the three *tori* - 47 (20.26%), followed by the individuals with TMx and TM - 41 (17.67%), TP and TMx - 25 (10.78%), and TP and TM - 24 (10.34%).

The X^2 test gave statistically significant results when we compare the frequencies of the individuals with three *tori* with the frequencies of the individuals with two *tori* (P = 0.00196), and when we compare individuals with three *tori* with individuals with one *torus* (P = 0.0206).

The Spearman test indicates that the association between TP and TMx ($r_s = 0.1393$, $p = 0.0202$) and TMx, and TM ($r_s = 0.1576$, $p = 0.0085$) are statistically significant. No association was found between TP and TM ($r_s = 0.0545$, $p = 0.3650$).

Discussion

The prevalence, morphology and association among *tori* of the Spanish sample in relation to the results obtained for other populations are analyzed and discussed.

It must be noted that most research works limit themselves to the prevalence of the appearance of these *tori* and their sexual dimorphism, while only some investigations take into consideration their morphologi-

cal variability (location, form, degree of development, and symmetry), and association.

The five subdivisions for humankind defined by Scott and Turner II (1997) have been used for the population comparison. We find this classification, elaborated to understand the variability of the dental morphology, the most adequate for our objectives. Humankind was divided into the following groups:

- Western Eurasia: includes the populations from peninsular Europe, the British Isles, Scandinavia, European Russia, the Near and Middle East, North Africa, and much of the Indian subcontinent.
- Sub-Saharan Africa: includes the populations from West Africa, South Africa, and the San.
- Sino-America: includes the populations from China-Mongolia, Northeast Siberia, South Siberia, Japan (Jomon and recent), American Arctic (Eskimo-Aleuts), Northwest North America (Indians), North and South America (Indians).
- Sunda-Pacific: includes the populations from Southeast Asia, Polynesia, and Micronesia.
- Sahul-Pacific: includes the populations from Australia, New Guinea and Melanesia.

Prevalence

Palatine *torus* Some authors state that Mongoloids and Eskimos (Sino-American populations) appear to have higher prevalence of TP than other populations (Woo, 1950; Seah, 1995). However, a detailed analysis of the prevalence of TP in Sino-American and Western-Eurasian populations shows a different conclusion. A diversity of frequencies has been found in Sino-American populations for this trait. So we find that the highest frequencies are for the Eskimos from San Lorenzo Island, with 66% of individuals with TP (Woo, 1950), and the lowest correspond to the Kackchiquel American Indians from Guatemala, with a prevalence of 0.2% (Escobar *et al.*, 1979). It is also interesting to consider that intra-population differences in the prevalence of TP have also been found. These are, for instance, the cases of Eskimos and Chinese. So, while high frequencies

of TP (66%) have been found in San Lorenzo's Eskimos (Woo, 1950), the prevalence of TP is less (18.3%) for another sample of Eskimos (Jarvis and Gorlin, 1972). In Chinese populations, a prevalence of 0.9% has been found for a sample from Hong-Kong (Nair *et al.*, 1996); while a prevalence of 48% has been obtained for a Singapore sample (Chew and Tan, 1984).

On the other hand, the Western Eurasian populations show an important variety of frequencies similar to what we find for the Sino-American populations. The highest prevalence is for the Portuguese population from Coimbra (Galera *et al.*, 1996) and the Lapps (Van den Broek, 1943-1945), both of them with 88% of TP, and the lowest frequencies, 9.2%, are for the Norwegians from the area of Oslo and the south-eastern part of the country (Haugen, 1992). High frequencies of TP have also been found in Italians, with a prevalence for the TP of 52%, in Croatians from Zagreb, with values of around 50% (Vidi , 1966), and for the Spanish sample taken in the present study. It is an interesting fact that all these Mediterranean populations show frequencies around 50% or higher. This supports the biological affinity among them, which has been shown previously in numerous morphological and molecular studies (Cavalli-Sforza *et al.*, 1994). The higher frequencies in the population from Coimbra could be due to the greater genetic homogeneity of this sample, since it is formed by individuals from the same city. For the rest of the European populations, the tendency observed is the one for those countries from northern and central Europe, for which we have several samples, like the case of Norway, Iceland, and Germany. When comparing several population groups of the same country, we find very dissimilar frequencies. So, for example, if we analyze carefully the case of Norway for the three samples studied, we find different frequencies. The obtained prevalence of TP were 38% for the islands of Lofoten, and 31.75% for a valley of the interior of the south of Norway (Eggen and Natvig, 1994), and 9.22% from a sample taken in Oslo (Haugen, 1992). These differences could be associated with the greater geographical isolation of two of the samples.

Studies of the Sub-Sahara African subdivision are scarce; however, they show the same inter- and intra-population variations that have been described before. The highest prevalence is for the Bantus from East Africa, with 41.3% of TP, and the lowest for a sample from Nigeria, formed mainly by Yoruba and Igbo, with 4.5% (Zivanovic, 1980).

Very little is known for Pacific populations; however, low prevalence of TP has been found for Australians (4.5%), Melanesians (0%), and Polynesians (5.1%) (Kellock and Parsons, 1970).

Maxillary *torus* Very few references on TMx have been found. Only nine samples have been studied for this *torus*: three of them are from Western Eurasia, three from Sino-America, and three from the Pacific. None has been found for the Sub-Sahara African populations. The highest frequencies are for the Portuguese sample from Coimbra (Galera *et al.*, 1996), where 74% of the individuals have TMx, and Spain (present study), with 44.2% of prevalence for this *torus*. Lapps have a prevalence of 17.5% (Schreiner, 1931-1935). Frequencies of TMx are low in Sino-American populations, 3.7% in Buriats, 2.2% in Aleutians, and 1.2% in Eskimos from the Kodiak Island (Hrdli ka, 1940), and very low in Pacific populations, 0.4% in Australians, and 0% in Melanesians and Polynesians (Kellock and Parsons, 1970).

Mandibular *torus* Although the highest frequencies of TM in Western Eurasia populations are from a small sample of Lapps (six individuals), with a prevalence of 83.3% (Hrdli ka, 1940), only 32.5% of individuals had TM in another and larger sample of Lapps (Schreiner, 1931-1935). The Portuguese sample from Coimbra with 55% of prevalence of TM (Galera *et al.*, 1996), and the Spanish sample (current study) with 54.7%, would really be considered the highest frequencies of this geographical area. The lowest frequencies appear in the Near East where a prevalence of 0% in a sample of 1932 individuals from Saudi Arabia and Yemen was found (Salem *et al.*, 1987).

The highest prevalence of TM in a Sino-America group is for Eskimos from one sample of Greenland (Sellevold, 1980), with 100% of individuals with *torus*. The Eskimos from the Aleutian Islands, and other samples from Greenland, also have high frequencies of TM, 65.9% and 52.7%, respectively (Frøhlich and Pedersen., 1992). The lowest prevalence are for several groups of Indians from Guatemala (Escobar *et al.*, 1979), and Argentina (Sedano, 1975), with 0% prevalence.

In Sub-Saharan Africa only five studies have been found. The highest prevalence of TM is for a Bushman sample from South Africa, with 26.9% of the individuals affected. The lowest frequencies are

for the Yoruba and Igbo from Nigeria, with a prevalence of 1.9% (Drennan, 1937).

Four studies have been found for the Pacific group, all of them indicating a low prevalence of TM. Three samples from Australia, New Guinea, and Tasmania showed prevalence for TM of 1.5%, 5%, and 11%, respectively (Fenner, 1939). Low frequencies of the Australian people were also found with a prevalence of 0.3% (Kellock and Parsons, 1970). The Polynesians show a prevalence of TM of 4.2% (Hrdli ka, 1940).

Trying to obtain some general conclusions, the maximal prevalence of the three oral *tori* in the five population subdivisions (Scott and Turner II, 1997) has been represented in Figure 1. A geographical distribution pattern appears clearly. The greatest prevalence of TP and TMx are found in the Western Eurasian Subdivision, while the TM has the greatest values in Sino-America. We also found high prevalence of TP and TM (between 41.3% and 26.9%) in Sub-Sahara Africa. The Pacific populations show low prevalence of the three *tori*, although we can not forget the very few numbers of researchers on this population subdivision.

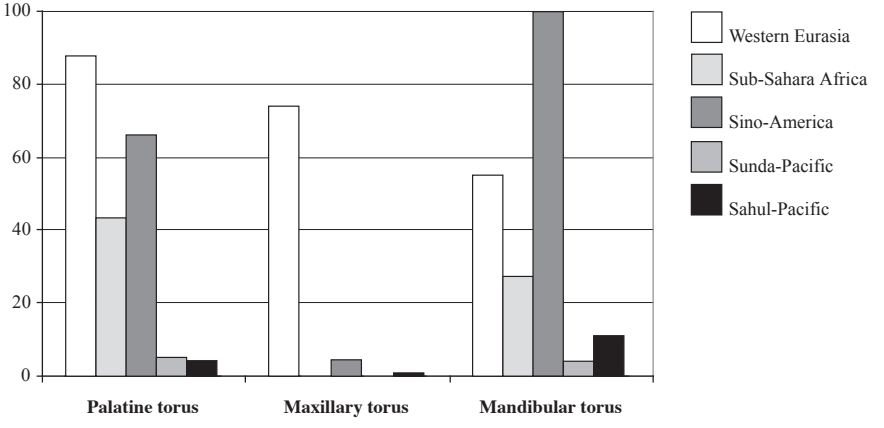

Figure 1. Maximal prevalence of the three oral tori in five subdivisions of the world populations.

It is important to point out that the comparison of the prevalence of the Spanish sample with other populations was complicated due mainly to the fact that we have more information from some geographical areas than others. Furthermore, the scarcity of studies on oral *tori*, especially on TMx, has complicated the possible interpretation of the data.

Anyway, all the previous discussions seem to support the importance of the genetic component of the oral *tori*, and lead us to think that it is that genetic component of the populations which, together with the evolutionary mechanisms related to the genetic isolation of some of these groups, those which have determined the geographical distribution of the prevalence of the oral *tori* in the populations studied.

The different theories of the environmental influence on the etiology of the oral *tori* have been also considered. The TP is the result of physiologic processes responding to functional demands or it is due to a hyperfunction of the masticating apparatus (Hrdli ka, 1940; Zivanovic, 1980). Some authors believe it is associated to a chemical irritation of the mucous (Van den Broek, 1943-1945), and/or to nutritional deficiencies (Schreiner, 1931-1935). Some others think that it is the type of diet (Axelsson and Hedegaard, 1985), and specially the components of the diet which are the responsible factors for the presence of these *tori* (Eggen and Natvig, 1994), not only taking into consideration the hardness of the diet component (masticatory stress), but also the components themselves. In the case of the TP, they conclude that it is the influence of certain nutrients of a type of marine diet that is responsible for the major expression of this *torus* in the Norwegian population of the Lofoten islands, with greater consumption of fish, against a population from the interior, like the valley of Gudbrandsdalen, with greater consumption of meat (Eggen and Natvig, 1994).

The analysis of the nutritional survey carried out with each of the individuals of the Spanish sample by means of a questionnaire about their dietary habits showed that all of them had a similar type of diet and nutritional habits. This type of diet is the Mediterranean one, characterized by the varied consumption of different types of food (olive oil, meat, fish, vegetables, legumes, pasta, bread, dairy products, and fruit), and it can be noticed that it is not a diet of hard components. As to nutritional habits, no important masticatory or functional stress was observed (high consumption of hard food, loss of dental pieces, malocclusions, oral habits that would produce some type of masticatory stress, etc.) that would be affecting the sample (Moreno, 2001).

As to the loss of dental pieces, it is interesting to note the interpretation of the results obtained for the two Norwegian populations of the Lofoten islands and the valley of Gudbrandsdalen. It was found that the frequency of the TM diminishes from age 50, and besides, that there is

an association among advanced years, loss of a greater number of dental pieces, and reduction of the incidence of the TM; and that it is also the maintenance of the masticatory function which is responsible for the presence of the TM, in such a way that when an individual loses his dental pieces, the processes of re-absorption would affect the expression of such *torus* (Eggen and Natvig, 1994). In this sense, we must also bear in mind that the TM cannot be observed when the re-absorption is advanced, and consequently, its frequencies could have been higher than the ones obtained (Galera *et al.*, 1996).

It could be concluded that the genetic component seems to be the main responsible factor for the high frequencies of *tori* obtained for the Spanish population.

Location

Palatine *torus* The studies carried out by several authors on populations of different origins have shown that the TP appears localized, with a high frequency, towards the middle of the palate and/or on the posterior zone, coinciding with the results that we have obtained in the Spanish sample. High frequencies of the TP affecting the middle zone of the palate have been found in a Chilean population (Witkop and Barros, 1963). In the majority of cases, the *torus* did not reach the ridged zone of the palate or the more posterior zone of it in English and North Americans of European origin (King and Moore, 1976). The TP has been found exclusively in the middle and posterior regions of a Chinese population (Chew and Tan, 1984), and Hindus (Shah *et al.*, 1992). Some high frequencies have been found of the TP placed along all the middle line of the palate (92.86% of the individuals with *torus*) as a consequence of the great variability and degree of development that this character shows in the Coimbra population (Galera *et al.*, 1996).

Maxillary *torus* The results obtained in the Spanish sample coincide with those various authors have obtained on Lapps and Japanese. In these populations, the TMx appears localized more frequently in the region of the molars, even behind the third molar, and can extend to the second premolar, but rarely reaches the canine (Hrdli ka, 1940; Woo, 1950). No

tori appear in the premolar, canine or incisive regions (Van den Broek, 1943-1945).

Mandibular *torus* Although this *torus* can appear in various regions of the mandible, the most frequent case is to find it in the canine, premolar, and molar regions, affecting various of them or just one, and, very rarely, in the incisive region (Hrdli ka, 1940). In the Spanish sample, this *torus* has, in all the cases, a middle location (canine and premolar regions), result which is similar to the ones of the majority of authors like, for instance, on Hindus, between first and second premolars (Shah *et al.*, 1992), on Greeks, between canine and first premolar (Karaiskos *et al.*, 1989), on Irish, between canine and second premolar (Clifford *et al.*, 1996), and on English and North-Americans of European origin, in the canine region (King and Moore, 1976). A minority of authors find that the TM appears in the molar region, on African populations of the South Sahara (Drennan, 1937), and on Portuguese (Galera *et al.*, 1996).

Form

Palatine *torus* The results obtained in the Spanish sample coincide with those on various groups, Mongols, American Indians, Eskimos, Americans of European and African origin (Woo, 1950); Chinese (Chew and Tan, 1984); Germans and Thai (Reichart *et al.*, 1988); Norwegians (Eggen and Natvig, 1994); and Portuguese (Galera *et al.*, 1996). All these authors state that the flat and spindle shapes are the most frequent. On the other hand, more frequencies of TP, called ridge-shaped category, which combines the flat and spindle shapes, and nodular with a high number of transitional forms, were obtained from Norwegians from the area of Oslo (Haugen, 1992).

Maxillary *torus* The bibliographic references found on this topic correspond to the works carried out by various authors on various populations. The TMx, when it is located on the lingual surface of the maxillary, presents irregular or lobular shapes, due to the presence of bumps more or less well marked (Hrdli ka, 1940; Woo, 1950). When the *torus* appears on the buccal surface it has a sausage shape with continuous surface

(Hrdli ka, 1940). All these data coincide fully with the results obtained in the present study for the Spanish sample.

Mandibular *torus*

The greater frequencies of the multiple TM which are obtained in the Spanish sample appear also in Chileans (Witkop and Barros, 1963), and Portuguese (Galera *et al.*, 1996). On the other hand, there are more frequencies of the simple TM in various North American groups (Levesque, 1965), Icelandic population (Axelsson and Hedegaard, 1985), and in Norwegians (Haugen, 1992).

Degree of development

Palatine *torus* The degree of development of the TP in the Spanish sample is low, that is, with high frequencies of palpable *torus*. These results coincide with those on various groups (Woo, 1950); Croats (Vidi , 1966); Chinese (Chew and Tan, 1984); Icelandic population (Axelsson and Hedegaard, 1985); Germans (Reichart *et al.*, 1988); and Norwegians (Eggen and Natvig, 1994). On the other hand, a high degree of development of this *torus* was obtained from the Portuguese of Coimbra (Galera *et al.*, 1996).

Maxillary *torus* Only one bibliographic reference was found on the degree of development of TMx. In various Siberian populations the frequencies of well marked TMx were very low (Hrdli ka, 1940). This information could coincide with the results of the Spanish population since, although the TMx was only determined by touch, it was found that all of them had a small degree of development. On the other hand, although the degree of development of this *torus* was not analyzed, it has been pointed out that in the Portuguese population of Coimbra, a great variation in its expression was observed (Galera *et al.*, 1996).

Mandibular *torus* The degree of development of the TM presents greater frequencies of the visible type, which is, marked in the Spanish population. These results coincide with those on Africans from the Sub-Sahara (Drennan, 1937), on various groups (Hrdli ka, 1940), and on Germans

and Thai (Reichart *el al.*, 1988). On the other hand, higher frequencies, with a small or average degree of development of the TM, were found on Portuguese (Galera *et al.*, 1996), and on English and North-Americans of European origin (King and King, 1981).

Symmetry

Maxillary *torus* The results obtained for the Spanish sample, considering that this *torus* is symmetric with respect to the left and right sides of the maxillary, coincide with those on Lapps (Schreiner, 1931-1935), and on Portuguese populations (Galera *et al.*, 1996). Also, it has been confirmed that the TMx is commonly bilateral, and that only in some exceptional cases it is unilateral (Hrdli ka, 1940; Van den Broek, 1943-1945). When we consider symmetry with respect to the buccal and lingual surfaces of one side, it has been shown that this *torus* appears with more frequency on the lingual side of the maxillary (Schreiner, 1931-1935; Woo, 1950) results which do not coincide with ours. The lingual location of the TMx, when it affects the third molar, can extend to the buccal surface (Van den Broek, 1943-1945). This *torus* does not appear on the two surfaces of the maxillary simultaneously, and higher frequencies for the *torus* on the buccal surface on various Siberian populations have been obtained (Hrdli ka, 1940), result which coincides with the ones in the present study. On the other hand, high frequencies of the *torus* affecting both surfaces simultaneously have been obtained on Portuguese population (Galera *et al.*, 1996).

Mandibular *torus* The results obtained in our sample coincide with the ones of many other authors who showed, for different populations, higher frequencies of the symmetric *torus*. Among these studies are those on Lapps, Chinese, Japanese, Australians, etc. (Hrdli ka, 1940); North Americans of European and African origin (Levesque, 1965); Chileans (Witkop and Barros, 1963); Germans and Thai (Reichart *et al.*, 1988); Greeks (Karaiskos *et al.*, 1989); Norwegians (Haugen, 1992); Portuguese (Galera *et al.*, 1996); and Irish (Clifford *et al.*, 1996). As to the cases in which an asymmetry in the Spanish population was determined, the left side was slightly more affected than the right one. Some authors have determined

that it is the right side the most frequently affected (Reichart *et al.*, 1988; Haugen, 1992).

Association among *tori.*

Palatine *torus* and mandibular *torus* No association of these two *tori* has been found in the Spanish sample, coinciding with some studies made by some authors on North Americans, where only 3.03% of individuals have both *tori* (Hrdli ka, 1940); Icelandic populations (Axelsson and Hedegaard, 1985); and Norwegians, where only 2.22% of individuals have both *tori* (Haugen, 1992). Other authors, on the other hand, have confirmed the existence of association between these characters. A Bushman population was found with a frequency of 66.7% of individuals with the two *tori* (Drennan, 1937). In the skeletal series of Americans of European and African origin, a greater percentage of TM has been obtained in those skulls that had TP than in those without it (Woo, 1950). On Norwegians, a significant association for the total sample has been found, but the analysis for sexes was significant only for females (Eggen and Natvig, 1994).

Palatine *torus* and maxillary *torus* The results obtained in the present study show an association between these two *tori*, coinciding with the work of some authors on North Americans, where a greater incidence of TMx in those skulls with the presence of TP than in those without it is obtained (Woo, 1950).

Mandibular *torus* and maxillary *torus* Although these two characters can coexist in the same individual, in the majority of cases this does not happen, but appears isolated (Hrdli ka, 1940). These results do not coincide with the ones obtained in this study, since, for the Spanish population; a very significant association for these two *tori* was obtained.

Association among the three *tori* The results obtained in the present study coincide with those obtained in a Lapp population with a high number of individuals with the three *tori* present (47 of 54 studied, Schreiner, 1931-1935); or in North American populations of European and African origin where there seems to be a certain correlation among these

three characters (Woo, 1950). In a Portuguese population, association among the three oral *tori* has also been obtained, not only in the total sample, but also in men and women analyzed separately, and in all the age groups that they have established, except in the immature category (Galera *et al.*, 1996).

Summary and Conclusions

In the present work the morphology and the prevalence of the *tori palatinu*s, *mandibularis,* and *maxillaris* were studied in a Spanish contemporary population sample, belonging to a middle-high socioeconomic level, and with ages between 19 and 29 years.

The detailed study of the morphology of each of these characters made it possible to establish the following criteria:

– The *torus palatinus* is less developed, and its more frequent localization is in the middle or middle-posterior parts of the palate, and its form was non-lobular in all the cases.
– The *torus maxillaris* was symmetric with respect to both sides of the maxillary, and asymmetric with respect to the faces, buccal (most frequently affected) and lingual of the same side. All the TMx presented the simple shape on the buccal face, and multiple on the lingual. The localization was middle-posterior on the buccal face, and posterior on the lingual.
– The *torus mandibularis* presented the greatest degree of expressivity and development of the three *tori*. It was symmetric in the majority of the individuals. The location was middle in all the cases, and the most frequent form was the multiple.

The analysis of the frequencies by which these three *tori* are present in the Spanish sample reveals the high prevalence of them, with maximum values for the TM (54.58%), and the absence of sexual dimorphism. This incidence, considered in the context of the data that is available at the moment for other European populations, leads us to support the hypothesis of the genetic origin as a fundamental etiological factor, and to question the idea that the oral *tori* happen with higher frequencies in populations from the Arctic and Sub-Arctic regions.

We believe that the interest of the topic treated here is unquestionable, as well as the novelty that is represented by the identification of high frequencies of oral *tori* in south western Europe, represented by the Portuguese population of Coimbra (Galera *et al.*, 1996) and the Spanish sample of the present study. The development of a new approach to allow us a better understanding of the complexity of these hyperostotic traits will be our plan for a future research.

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