

Prevalence of Torus Mandibularis in Viking Age Icelanders

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Abstract

Of 48 available crania dated older than 1104AD, from the archaeological site of Skeljastadir in Thorsardalur, Iceland, 24 (50%) had torus mandibularis. There was no sex difference observed. The prevalence is similar among other populations in the northern hemisphere from the same time period. According to a number of authors, environmental and functional factors, particularly high masticatory activity, play a predominant part in the etiology. People from arctic- and subarctic areas survived on an animal diet, mostly fish and meat, but people living further south in a more temperate climate had more of an agricultural diet. Higher prevalence was found in the age group above 36 years than in the group 35 years and below. The majority of the tori were small or medium in size. The most frequently occurring variant was the multiple bilateral form, followed by the multiple unilateral form. The prevalence of torus mandibularis in the study was much higher than found in modern Iceland.

Keywords: Torus Mandibularis; Viking Age Icelanders

Introduction

Torus mandibularis is a bony protruberance or exostosis on the lingual surface of the mandible, above the mylohyoid ridge, generally situated in the canine and the premolar region. The trait can occur unilaterally or bilaterally, with symmetrical occurrence visible as either as a single elevation or

as multiple fused or separate tubercles of variable sizes (1, 2).

According to a great number of authors (3-10), environmental and functional factors, particularly high masticatory activity, play a predominant part in the etiology. More recently authors have considered genetic mechanisms as crucial in the etiology(11-14).

Ethnic group differences, regarding the occurrence of torus mandibularis, are at least as predominant as the condition in torus palatinus. Both torus mandibularis and torus palatinus have high prevalence in several groups of Mongol origin with the incidence being generally higher among those in the northern hemisphere (8, 12). In American Indians, Chinese and Japanese, the prevalence is lower than in the Arctic Mongol population (Eskimos), most often between 10-15% (3, 5). In the Caucasian population, the frequency is still lower, ranging from 2-3% up to 7-8%, the latter level more common. In the North American black population the prevalence is near the same or slightly higher (15).

Age at onset varies among populations. Early appearance has been reported in Aleuts (16), Eskimos (5, 8) and Lapps (17), but in the Eskimos of Wainwright, Alaska, torus mandibularis generally does not appear before the age of 40 (7).

In 1939 at Skeljastadir site in Thjorsardalur valley near volcano Hekla in Iceland, sixty-six skeletons were excavated from a Christian graveyard (18). The dating of occupation of Skeljastadir is like many other archaeological sites in Iceland, mainly based on the tephra (volcanic ash) chronology from the eruption of Hekla 1104 (19). The purpose of the present study is to establish the prevalence of torus mandibularis in this medieval Icelandic population and to compare the results with other studies of medieval material in Iceland and other countries. We also intend to compare the results with the frequency observed in modern Icelanders.

Materials and methods

The skeletons excavated at Skeljastadir were quite well preserved and Jón Steffensen, an Icelandic anthropologist who originally investigated the bony material, determined that there were 27 men, 28 women, 2 children and 5 infants (20). The skeletons were dated from after the year 1000 when Iceland was Christianized, till the Thorsardalur valley became uninhabitable because of the volcanic eruption from the mountain Hekla in 1104. Of the 63 skeletons excavated, forty eight were available for research.

The adult skeletons were sexed using morphological characteristics from skull and in few instances from pelvis (21). For age estimation four methods were used based on developmental stages of teeth (22-25), one of regressive changes in teeth (26), one on tooth wear (27, 28) and one on ectocranial suture closure (29).

The tori were registered according to sex and two categories of age, 35 years and below and 36

years and older. All tori were measured in millimeters with a slide calliper and a periodontal probe and the location on the mandible registered.

For the purpose of comparison with former investigations an attempt was made to classify the tori in three categories according to size, small, medium and large. The criteria used was the one given by Woo as shown in Table 1 (30).

Torus mandibularis were also categorized as to whether the bony nodules were single or multiple. Thus four categories of form were registered: unilateral single, unilateral multiple, bilateral single and bilateral multiple.

All scoring procedures and measurements were conducted by one investigator, thus preventing inter-observer error.

Results

Of the 48 observable skeletons 24, or 50%, had torus mandibularis. The distribution between sexes was 12 male and 12 female. The prevalence is presented in Table 2 according to age and sex.

The distribution of torus mandibularis according to size and sex is presented in Table 3, showing medium sized tori are most common. The results are presented in percentage of the tori recorded and the number of skeletons in the group.

The distribution of torus mandibularis according to location and sex is presented in Table 4. The results are presented in percentage of the tori recorded and the number of observable skeletons in the group. Bilateral occurrence is much more common than unilateral, observed in 9 (62.5%) out of 12 skeletons. Unilateral occurring tori is twice as common on the left side.

The distribution of torus mandibularis according to morphology of the tori and sex is shown in Table 5. The multiple form is more common, regardless of whether it occurs unilaterally or bilaterally.

Discussion

Prevalence of torus mandibularis in the Skeljastadir population compared with other groups of Icelanders and related racial groups is summarized in Table 6.

In Table 7 the prevalence of torus mandibularis in the present study is compared with different racial groups (all age groups) in modern times according to sex.

In Table 8 and 9 the distribution of torus mandibularis from different time periods in Iceland are presented according to age and sex. The results are presented in percentage of the tori recorded and the number of skeletons in the group.

Iceland was settled in the Viking age period, mostly from the west coast of Norway and the Viking colonies in Scotland, Ireland and the British Isles. Among the settlers were also Celts, Swedes and

Danes (2, 31). Geographic isolation and known hereditary background make Icelanders interesting population for the study of racial trait such as torus mandibularis.

The high prevalence of torus mandibularis in the oldest Steffensen material (66.2%) with approximate chronology 900-1000 and the 50.0% in the present study is surprising considering the much lower prevalence in Norway, Sweden and Ireland (Table 6). Unfortunately the frequency in Norway is not known at the time of settlement in Iceland, and it may have been higher at that time. It is believed that most of the people emigrating to Iceland were from the west coast of Norway, where the prevalence could possibly have been higher than in the Oslo area (2). It is, however, interesting that 50% of skulls from an Irish study had torus mandibularis (32). Two Icelandic settlements were founded in Greenland shortly after Iceland was first inhabited (31). As expected, the occurrence of torus mandibularis in Greenland and Iceland was similar (table 6).

Although the prevalence of torus mandibularis rose during the first centuries of habitation in Iceland a decline was later observed. In 1962 John Dunbar found torus mandibularis in 8.8% of dentate (\geq one tooth) Icelanders (Table 6) (33). If the Axelsson and Hedegård's results in Table 6 are compared to Dunbar's 5-19 years age group, a striking difference is noticed. Either the prevalence in North and South Thingeyjarsýslas is well above the mean for the nation, or the difference is caused by a large inter-investigator error or (more likely) different diagnostic criteria. Furthermore if the prevalence measured in living Icelanders and the prevalence found in the skull material is compared, there is a large decline. One explanation could be that it is much easier to diagnose tori on skeletal material than in living persons, especially the smaller ones. There is also considerable difference in prevalence observed between this study and other studies on torus mandibularis in Icelanders from similar time. One explanation could be that in this study a well-qualified dentist was responsible for all the diagnosis and measurements. In the other studies non-dental examiners conducted the examinations. What also makes this study more trustworthy is that the skulls were photographed from all angles and the diagnosis and the measurements verified. If there was doubt, the skulls were remeasured.

Steffensen (9) reported a correlation between diet and the prevalence of torus mandibularis among Icelanders. The growing of cereals gradually decreased due to an increasingly colder climate and around 1600 grain crops were no longer produced. Thus the diet was characterized more by meat, fish, milk and dairy products with simultaneous increase in the frequency of torus mandibularis. A decrease in prevalence of torus mandibularis was observed with increased importation of cereal, sugar and other vegetable products, which began around 1600. A similar decrease in the incidence following a change from coarse native diet to a softer modern one has also been reported elsewhere (7, 8).

Although the incidence of torus mandibularis among Icelanders suggests a strong influence of predisposing or environmental factors such as the composition and preparation of the diet, it has been shown in several well documented studies that torus mandibularis has a genetic component (12, 14, 34). The role of diet in the expression of this trait has been difficult to study in populations

where there are dietary differences in genetically homogenous populations. In the study by Axelsson and Hedegaard, two isolated rural counties in Iceland with an identical exhibited a difference in the number of torus mandibularis for the same age groups which was almost threefold, suggesting or supporting a genetic difference.

The Peabody Museum at Harvard University possesses a collection of skeletal remains from Iceland consisting of 1 complete skeleton, 2 incomplete skeletons, 3 skulls with mandibles, 80 skulls without mandibles, including 60 in fairly good condition, 62 odd mandibles, and a large number of long bones and other skeletal parts (4). Hooton (4) investigated this collection and in his article "On certain Eskimoid characters" he discussed striking resemblances to Eskimo characters exhibited in this Icelandic collection, which he considered were probably not racial characters, but rather environmental adaptations among people living in the Arctic or sub-Arctic regions and living primarily on a diet of fish and flesh. These characters are torus mandibularis, torus palatinus, the thickened tympanic plate and the scaphoid skull vault. He considered this a mechanical adaptation due to excessive development of the masticatory apparatus (4).

Hooton divided torus mandibularis into four categories according to size; slight, medium, pronounced and very pronounced. The "slight" class included mandibles which exhibited small and isolated borders of the alveolar processes (4).

In Table 10, Hooton divides torus mandibularis found in Icelanders and Eskimos into four categories according to size of the tori. The skeletal material is dated from the age period 1000-1563 (4).

In Table 11 torus mandibularis is divided in three categories according to size.

In Table 10 it can be seen that 87.1% of the Eskimo mandibles exhibited some degree of torus mandibularis, 20% more than in the Icelandic material (table 11). These results agree with that of Fürst (35) who in a large collection of Eskimo crania, found about 80% with mandibular torus. Hooton stated: "As would be expected, the more pronounced development of the character is relatively more frequent in Eskimo than in Icelanders. In the Icelandic mandibles the torus is more composed of isolated ridges and knobs than in the Eskimo, with whom it is usually continuous" (4).

Hooton was convinced that torus mandibularis was an environmental adaptation and not a racial trait. He compared his results with the results made on Italian crania as it was desired to compare them with skulls of Europeans of approximately the same period living in more temperate climates Table 10, (4).

Fischer-Möllers (36) study on 56 crania from the Western settlement of Icelanders in Greenland, dated 1275-1350, shows that 37 or 66.1% had torus mandibularis. Of these 14 or 37% were "severe". Hooton (4) found torus mandibularis in 67.9% of Icelanders, almost the same percentage as in the Western settlement. Fürst and Hansen (35) found torus mandibularis in 85% and Fischer-Möller in 77.1% amongst Greenland Eskimos. For Lapps, Shreiner (17) reports 32.5%. Fisher-Möller (36) states that torus mandibularis is more common among Icelanders, Greenland Norsemen, Eskimos and Lapps, than among other people. His explanation was that these people

lived more or less on the same animal diet of fish, marine mammals, caribou (reindeer) and bears, with the addition of milk and milk products for Icelanders and Norse colonists.

Steffensen (37) stated that there could be a correlation between dental wear as a result of a heavy masticatory forces and torus mandibularis(37). There was not a significant correlation in the present study between these two traits.

In the study by Axelsson and Hedegaard (2) in Thingeyjarsýslas in modern times, the prevalence of the single bilateral form was by far the most frequent. This same result was found in the study by Haugen on Norwegian population in modern times (1). Hooton, Steffensen and Dunbar all investigated torus mandibularis in Icelandic material, Hooton and Steffensen investigated medieval skeletal mandibles and Dunbar examined living material in modern time, and have not published any results on torus mandibularis according to size or morphology (4, 20, 33). In the Skeljastadir population, the most frequently occurring variant of torus mandibularis is the multiple bilateral form (Figure 1), followed by the multiple unilateral form. The prevalence of the multiple form of torus mandibularis is twice as high as the single form both unilaterally and bilaterally. The present authors have no explanation of the different results of the aforementioned studies. The results are compared in Table 11.

Acknowledgements

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	Elevation (mm)	Width (mm)	Length (mm)
Small	Under 3	Under 10	Under 15
Medium	3–5	10–15	15–25
Large	Above 5	Above 15	Above 25

Table 1 Criteria of categories according to size

Sex	Age	n skeletons	n with tori	% with tori	Total % with tori
Female	35 years and below	10	4	40,0	50
	36 years and above	14	8	57,1	
Male	35 years and below	5	3	60,0	50
	36 years and above	19	9	47,4	
Both sexes	35 years and below	15	7	46,7	50
	36 years and above	33	17	51,5	

Table 2 Prevalence of torus mandibularis according to two age groups in both sexes

Size	Females			Males			Females + males		
	Number of tori	% of tori	% of skeletons n = 24	Number of tori	% of tori	% of skeletons n = 24	Number of tori	% of tori	% of skeletons n = 48
Small	2	16,7	8,3	7	58,3	29,2	9	37,5	18,8
Medium	7	58,3	29,2	5	41,7	28,3	12	50,0	25,0
Large	3	25,0	12,5	0	0	0	3	12,5	6,3
Total	12	100,0	50,0	12	100,0	50,0	24	100	50,0

Table 3 Prevalence of torus mandibularis according to size and sex

Location	Females			Males			Females + males		
	Number of tori	% of tori n = 12	% of skeletons n = 24	Number of tori	% of tori n = 12	% of skeletons n = 24	Number of tori	% of tori n = 24	% of skeletons n = 48
Right	1	8,3	4,2	2	16,7	8,3	3	12,5	6,2
Left	2	16,7	8,3	4	33,3	16,6	6	25,0	12,5
R. + L.	9	75,0	37,5	6	50,0	25,0	15	62,5	31,3
Total	12	100,0	50,0	12	100,0	50,0	24	100,0	50,0

Table 4 Prevalence in percentages of torus mandibularis according to location and sex

	Females	Males	Females + males
Unilateral single		3	3
Unilateral multiple	3	3	6
Bilateral single	3	1	4
Bilateral multiple	5	4	9

Single one side, multiple other side	1	1	2
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Table 5 Prevalence of torus mandibularis according to morphology and sex

Racial groups	Approximate chronology	N	%	Investigator
Icelanders	900-1100	133	66,2	Steffensen (9)
Icelanders (Skeljastadir)	< 1104	49	50,0	Present study
Icelanders	1100-1650	55	81,1	Steffensen (9)
Icelanders	1650-1840	67	44,8	Steffensen (9)
Icelanders	1000-1563	56	67,9	Hooton (4)
Icelanders (Eastern settlement, Greenland)	1100-1200	12	50,0	Bröste et al. (38)
Icelanders (Western settlement, Greenland)	1275-1350	56	66,1	Fisher-Møller(36)
Icelanders	1962	2508	8,8	Dunbar (33)
Icelanders (South-Thingeyjarsysla)	1973-1975	763	30,0	Axelsson and Hedegård (2)
Icelanders (North Thingeyjarsysla)	1973-1975	213	12,7	Axelsson and Hedegård (2)
Norwegians (Oslo)	Middle Ages	100	17,0	Schreiner (17)
Swedes (Halland and Scania)	1000-1700	963	2,7	Mellquist and Sandberg (39)
Irishmen (Gallen Priory)	700-1600	99	50,5	Howells (32)

Table 6 Prevalence of torus mandibularis in Icelanders and related racial groups

Population	♂		♀		♀ + ♂		Authors
	No.	%	No.	%	No.	%	
Brazilian Indian	100	0,5	100	0,5	200	0,5	Bernaba (40)
Canadian Eskimo	382	42,1	415	32,3	797	37,0	Jarvis and Gorling (11) ¹
Alaskan Eskimo	86	17,4	82	3,7	168	10,7	Mayhall et al. (7)
Aleut	57	42,1	51	27,5	108	35,2	Moorrees (16)
Japanese	834	38,4	156	51,9	990	40,5	Sakai (41) ²
Chilean					1.906	0.05	Witkop and Barros (42)
American Negro	696	5,3	813	10,9	1.509	8,2	Austin et al. (15)
American Negro	446	6,1	510	7,7	956	7,9	Shaumann et al. (43)
American Caucasian 1964			295	15,9			Summers (44) ³
American Caucasian					2.064	7,9	Kolas et al.(45)
Icelanders 1962	1.364	9,5	1.147	7,9	2.511	8,8	Dunbar (33)
Icelanders, Skeljastadir	24	50,0	24	50,0	48	50,0	Present study

¹Over 13 years.

²Eighteen years and older.

³Eight to sixteen years.

Table 7 Prevalence of torus mandibularis in modern time in different racial groups according to sex compared to present study

	Age	Torus Mandibularis					
		♂		♀		♀ + ♂	
		n	%	n	%	n	%
Skeletons 900-1840 Steffensen (9)	12-18	8	38	10	20	18	28
	18-30	30	43	39	64	69	55
	30-50	85	61	62	79	147	68,7
	> 50	23	57	14	64	37	59,5
Skeletons 1000-1563 Hooton (4)						56	67,9
Skeljastaðir - Present study < 1104	< 35	5	60,0	10	40,0	19	46,7
	≥ 35	19	47,4	14	57,1	35	51,5
Living - 1962 Dunbar (33)	5-19	251	5,6	257	4,9	508	5,3
	20-34	202	7,5	185	9,2	387	8,3
	35-49	457	10,9	382	12,0	839	11,4
	> 49	454	11,2	323	4,7	777	8,5
Living - 1973-5. S. Thingeyjarsýsla Axelsson and Hedegård (2)	6-17	385		378		763	30,0
Living - 1973-5. N. Thingeyjarsýsla Axelsson and Hedegård (2)	6-17	104		109		213	12,7

Table 8 Prevalence of torus mandibularis in Iceland according to age and sex

Race		Absent	Slight	Medium	Pronounced	Very pronounced	Total
Icelanders	N	18	16	9	8	5	56
	%	32,1	28,6	16,1	14,3	8,9	67,9
Eskimo	N	4	8	7	7	5	31
	%	12,9	25,8	22,6	22,6	16,1	87,1
Italians	N	29	1	0	0	0	33
	%	96,7	3,3	0,0	0,0	0,0	3,3

Table 9 Prevalence of torus mandibularis in Icelanders and Eskimos according to size

Icelanders		Absent	Small	Medium	Large	Total
Skeljastadir present study	N	24	9	12	3	48
	%	50	19	25	6	100

Table 10 Prevalence of torus mandibularis in the Skeljastadir material according to size

Population	Morphology	♀	♂	♀ + ♂	Investigator
North- Thingeyjarsysla 1973-75	Unilateral single	3	7	10	Axelsson and Hedegård (2)
	Unilateral multiple	0	0	0	
	Bilateral single	13	3	16	
	Bilateral multiple	0	1	1	
	Single one side, multiple other side	0	0	0	
South- Thingeyjarsysla 1973-75	Unilateral single	18	34	52	Axelsson and Hedegård (2)
	Unilateral multiple	0	0	0	
	Bilateral single	77	87	164	
	Bilateral multiple	4	2	6	
	Single one side, multiple other side	4	3	7	
Skeljastadir < 1104	Unilateral single		3	3	Present study
	Unilateral multiple	3	3	6	
	Bilateral single	3	1	4	
	Bilateral multiple	5	4	9	
	Single one side, multiple other side	1	1	2	

Table 11 Morphological classification of torus mandibularis in the present study compared with the results from Thingeyjarsyslas from modern time



Figure 1 The most frequent form of torus mandibularis in the study was the multiple bilateral form