Oral Tori Are Associated With Local Mechanical and Systemic Factors: A Case-Control Study

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Purpose: To estimate if various dental factors, medications, and medical conditions are associated with an increased risk for the presence of oral tori.

Materials and Methods: Using a case-control study design, the investigators identified and adjudicated a sample of cases with torus palatinus (TP) and/or torus mandibularis (TM) during a 1.5-year period. The medical records were abstracted and data on dental factors, temporomandibular dysfunction (TMD), medications, and medical conditions were recorded. Risk estimates were calculated as adjusted odds ratios (AORs) with 95% confidence intervals (CIs) using conditional logistic regression analyses, and the *P* value was set at .05.

Results: The sample was composed of 66 subjects with TM, 34 subjects with TP, and 100 control subjects from the same database. Any form of oral torus (TP and/or TM) was associated significantly with TMD (AOR, 10.51; 95% CI, 4.46 to 24.78; $P < .01$) and tooth attrition (AOR, 5.22; 95% CI, 2.32 to 11.77; $P < .01$). TP was associated significantly with TMD (AOR, 4.14; 95% CI, 1.21 to 14.21; $P < .05$), tooth attrition (AOR, 38.18; 95% CI, 7.20 to 202.41; $P < .01$), and treated hypertension (AOR, 6.64; 95% CI, 1.31 to 33.57; $P < .05$). TM was associated significantly with TMD (AOR, 5.77; 95% CI, 2.38 to 13.98; $P < .01$), tooth attrition (AOR, 6.69; 95% CI, 2.78 to 16.14; $P < .01$), and a penicillin allergy (AOR, 4.45; 95% CI, 1.05 to 18.83; $P < .05$).

Conclusions: This study provides clinical evidence showing significant associations between oral tori and various dental factors, medications, and medical conditions. These findings add to the list of environmental factors believed to contribute to the formation of oral tori.

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The control of bone quantity and quality in the oral environment is essential for the success of dental implantation and bone and soft tissue grafting procedures. Much research has been dedicated to developing new surgical techniques and materials for alveolar ridge augmentation. Interestingly, the body can produce its own ectopic oral bone, as seen with oral tori, but this process is poorly understood.

Two of the most common oral exostoses are the torus palatinus (TP) and the torus mandibularis (TM). Oral tori are benign developmental anomalies, or hamartomas, having no pathologic significance and consisting of dense cortical bone with a limited amount of bone marrow.[1,2] The TP is found on the midline of the hard palate, and the TM appears on the lingual aspect of the mandible, above the mylohyoid line, in the canine/premolar region.[2] These bony outgrowths are covered by a thin and poorly vascularized mucosa. They tend to grow slowly and continuously, but have been found to stop growing spontaneously in the absence of teeth.[2] Oral tori are usually discovered incidentally during a routine clinical examination because they rarely produce symptoms.[3]

The prevalence of oral tori has been reported to be 12% to 15%.[4,5] A strong association has been found between the TP and the TM, whereby 50% of subjects with a TM had a concurrent TP and 30%

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of subjects with a TP also had a TM.[4] The growth of these bony lesions typically begins during puberty, but may begin as late as 30 to 50 years old, and they slowly enlarge into adulthood.[6] The TP and TM are generally first noticed in older subjects, at an average age of 34 to 39 years old.[4,5] Furthermore, the TP has been found to appear more frequently in women, whereas the TM is more common in men.[4,5,7,8]

Surgical removal is often not necessary for an oral torus unless it has reached a size large enough to interfere with speech, mastication, the construction of a dental prosthesis, or if it is prone to traumatic ulceration. In cases of severe periodontal disease, the removal of oral tori may be recommended to enhance periodontal pocket elimination and to allow better access for oral hygiene.[1] In addition, these lesions may be excised for clinical crown lengthening, for site preparation before removable denture fabrication, or to obtain heterogeneous bone for grafting purposes.[9-11]

Insight into the process of ectopic oral bone formation, as with oral tori, could assist in developing less invasive methods for alveolar ridge augmentation and the natural enhancement of bone quality for dental implant placement. However, an accepted mechanism for the development of oral tori is not known despite the high prevalence of these bony outgrowths. The exact etiology of oral tori has eluded investigators for decades, but it is believed that the trait (TP and/or TM) is expressed when a certain threshold of genetic and local environmental factors is surpassed.[4,5,8,10,12-21] Historically, studies on the etiology of these bony lesions have focused on genetic and environmental influences, but have neglected to investigate the broad scope of interdependent factors involved in bone metabolism. The purpose of this investigation was to undertake a broader assessment of potential environmental influences and, in doing so, address the following question: in subjects with oral tori, are there associations with various dental factors, medications, and medical conditions compared with control subjects? The authors hypothesized that the presence of oral tori would be associated with a greater risk for tooth attrition, temporomandibular dysfunction (TMD), medical conditions, and certain pharmacologic agents compared with the absence of oral tori. To test this hypothesis, the authors implemented a case-control study.

Materials and Methods

A case-control study was conducted using subjects attending the McGill University Undergraduate Teaching Clinic, Faculty of Dentistry, at the Montreal General Hospital. This study followed the Declaration of Helsinki on medical protocol and ethics, and approval was granted from the ethics committee of the McGill University Health Center, Montreal, Quebec. The electronic dental records of the subjects were searched and the original hard copy files were retrieved for manual examination. The study period was from July 1, 2010, to January 30, 2012.

CASE DEFINITION AND VALIDATION

The authors identified subjects who had a TP and/or a TM as recorded in the computerized database during the study period. A TP was recorded as present when an asymptomatic bony outgrowth was clinically visible on the midline of the hard palate, consistent with the typical presentation.[2] A TM was recorded when an asymptomatic bony outgrowth was clinically visible on the lingual aspect of the mandible in the canine/premolar region, consistent with the typical presentation.[2] Subjects were excluded from the case group if the dental records did not describe intra- and extraoral examinations, a full medical history, a list of current and previous medications, details for any parafunctional habits, and a complete odontogram.

CONTROLS

Control subjects matched to cases by entry date, gender proportion, and age range were selected from the computerized database within the same study period. Subjects were excluded from the control group if they had an oral torus. Furthermore, subjects were excluded if the dental records did not describe intra- and extraoral examinations, a full medical history, a list of current and previous medications, details for any parafunctional habits, and a complete odontogram.

MEASUREMENTS

The following measurements were recorded: age, gender, hypertension, hypothyroidism, type 1 or 2 diabetes mellitus, respiratory problems (asthma and obstructive sleep apnea), periodontal disease, penicillin allergy, anxiety/depression, smoking habit, TMD, and signs of tooth attrition. A history of periodontal disease was recorded for any subject having an overall periodontal screening and recording score of 3 or 4.[22] Signs of tooth attrition were noted for clinically evident, atypical wear patterns on incisal edges and cusp tips, consistent with attrition resulting from parafunction.[23-25] Evidence of TMD was determined according to established diagnostic guidelines.[26-29] These signs and symptoms included uni- or bilateral clicking and/or crepitus of the temporomandibular joint(s) and/or tenderness to palpation of the preauricular area and muscles of mastication. Typical

Table 1. FREQUENCIES OF CHARACTERISTICS OF CASE SUBJECTS VERSUS CONTROL SUBJECTS

Characteristics	Controls	TP and/or TM	TP	TM
	Percentage (95% CI)	Percentage (95% CI)	Percentage (95% CI)	Percentage (95% CI)
Age (yr)	53.6 (50.9-56.3)	47.2 (42.9-51.6)	44.5 (36.7-52.3)	47.3 (42.6-52.0)
Men	51 (41-61)	41 (31-51)	32 (16-49)	41 (30-52)
Smokers	8 (3-13)	7 (1-12)	6 (−2 to 14)	7 (2-13)
Attrition	23 (15-31)	59 (49-69)	62 (45-79)	58 (47-69)
TMD	14 (7-21)	44 (34-54)	44 (27-62)	47 (36-58)
Periodontal disease	43 (33-53)	36 (26-46)	32 (16-49)	37 (27-48)
Hypertension	21 (13-29)	23 (15-31)	26 (11-42)	22 (13-31)
Penicillin allergy	5 (1-9)	8 (3-13)	3 (−3 to 9)	8 (2-15)
Respiratory problem	4 (0-8)	9 (3-15)	6 (−2 to 14)	10 (3-16)
Hypothyroidism	3 (0-6)	8 (3-13)	15 (2-27)	6 (1-11)
Diabetes mellitus	8 (3-13)	5 (1-9)	3 (−3 to 9)	5 (0-10)
Anxiety/depression	4 (0-8)	7 (2-12)	6 (−2 to 14)	7 (2-13)

Abbreviations: CI, confidence interval; TM, torus mandibularis; TMD, temporomandibular dysfunction; TP, torus palatinus.

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pharmacologic agents observed included antihypertension medications, thyroid hormone replacement medications, antihyperglycemics, β2-adrenergic receptor agonists (as used for the treatment of asthma), continuous positive airway pressure (as used for the treatment of obstructive sleep apnea), anxiolytics, and antidepressants.

STATISTICAL ANALYSES

The authors conducted conditional logistic regression analyses using IBM SPSS Statistics 19 (SPSS, Inc, Chicago, IL). Risk estimates were presented as odds ratios (ORs) with 95% confidence intervals (CIs). The ORs were adjusted for the potential confounders of age, gender, hypertension, hypothyroidism, type 1 or 2 diabetes mellitus, respiratory problems (asthma and obstructive sleep apnea), periodontal disease, penicillin allergy, anxiety/depression, smoking habit, TMD, and signs of tooth attrition. P values were 2-sided and were considered statistically significant if less than .05.

Results

In searching the computerized medical records, 236 subjects were identified as having some form of torus. Those who satisfied the case selection criteria included 34 subjects with TP and 66 subjects with TM, of which 17 subjects had TP and TM concurrently. From the same database, 211 subjects were identified as not having any form of torus within the study period, and 100 of these subjects met the control selection criteria.

The characteristics of the case and control groups are presented in Table 1, and the unadjusted ORs are listed in Table 2. Case subjects showed a higher prevalence of tooth attrition and TMD compared with control subjects (Table 1). Subjects with tooth attrition and TMD displayed an increased risk for the presence of oral tori, and those with hypothyroidism showed an increased risk for the presence of TP (Table 2). Case subjects did not differ from controls in age, gender, smoking status, hypertension, periodontal disease, penicillin allergy, type 1 or 2 diabetes mellitus, respiratory problem, or anxiety/depression.

Case subjects with any form of torus (TP and/or TM) had an age range of 12 to 87 years (mean, 47.2 ± 4.4 years; Table 1). Of the 100 subjects with a torus, 41 (41 ± 10%) were male. Subjects with TMD (adjusted ORs [AORs], 10.51; 95% CI, 4.46 to 24.78; $P <$ .01) and tooth attrition (AOR, 5.22; 95% CI, 2.32 to 11.77; $P <$ .01) showed an increased risk for the presence of any form of oral torus (TP and/or TM; Fig 1). No other subject characteristics assessed were associated with an increased risk for the presence of any form of oral torus (TP and/or TM).

Subjects with TP had an age range of 14 to 83 years (mean, 44.5 ± 7.8 years; Table 1). Of the 34 subjects with TP, 11 (32 ± 17%) were male. The subjects with tooth attrition (AOR, 38.18; 95% CI, 7.20 to 202.41; $P <$ .01), TMD (AOR, 4.14; 95% CI, 1.21 to 14.21; $P <$ .05), and treated hypertension (AOR, 6.64; 95% CI, 1.31 to 33.57; $P <$ .05) showed an increased risk for the presence of TP (Fig 2). Interestingly, subjects with hypothyroidism (AOR, 6.54; 95% CI, 0.814 to 52.625; $P =$ .08) also showed an increased risk for having TP, but not within the range of statistical significance.

Subjects with TM had an age range of 12 to 83 years (mean, 47.3 ± 4.7 years; Table 1). Of the 66 subjects with TM, 27 (41 ± 11%) were male. The subjects with tooth attrition (AOR, 6.69; 95% CI, 2.78 to 16.14; $P <$ .01), TMD (AOR, 5.77; 95% CI, 2.38 to 13.98; $P <$ .01), and a penicillin allergy (AOR, 4.45; 95% CI, 1.05

Table 2. UNADJUSTED ODDS RATIOS FOR CHARACTERISTICS OF CASE SUBJECTS VERSUS CONTROL SUBJECTS

		TP and/or TM		TP		TM	
	n	n	OR (95% CI)	n	OR (95% CI)	n	OR (95% CI)
Gender							
Female	49	59	1.00	23	1.00	36	1.00
Male	51	41	0.67 (0.38-1.17)	11	0.46 (0.20-1.04)	30	0.80 (0.43-1.49)
Smokers							
No	92	93	1.00	32	1.00	61	1.00
Yes	8	7	0.87 (0.30-2.49)	2	0.72 (0.15-3.56)	5	0.94 (0.29-3.02)
Attrition							
No	77	41	1.00	13	1.00	28	1.00
Yes	23	59	4.81 (2.61-8.89)*	21	5.41 (2.35-12.45)*	38	4.54 (2.31-8.92)*
TMD							
No	86	66	1.00	19	1.00	37	1.00
Yes	14	44	4.83 (2.42-9.62)*	15	4.85 (2.01-11.71)*	29	4.82 (2.29-10.14)*
Periodontal disease							
No	57	64	1.00	23	1.00	41	1.00
Yes	43	36	0.746 (0.42-1.32)	11	0.63 (0.28-1.44)	25	0.81 (0.43-1.53)
Hypertension							
No	79	77	1.00	25	1.00	52	1.00
Yes	21	23	1.12 (0.58-2.20)	9	1.35 (0.55-3.33)	14	1.01 (0.47-2.17)
Penicillin allergy							
No	95	92	1.00	33	1.00	59	1.00
Yes	5	8	1.65 (0.52-5.24)	1	0.58 (0.07-5.11)	7	2.25 (0.68-7.43)
Respiratory problem							
No	96	91	1.00	32	1.00	59	1.00
Yes	4	9	2.37 (0.71-7.98)	2	1.50 (0.26-8.58)	7	2.85 (0.80-10.15)
Hypothyroidism							
No	97	92	1.00	29	1.00	63	1.00
Yes	3	8	2.81 (0.72-10.92)	5	5.58 (1.26-24.74)*	3	1.54 (0.30-7.87)
Diabetes mellitus							
No	92	95		31	1.00	64	1.00
Yes	8	5	0.61 (0.19-1.92)	1	0.35 (0.04-2.89)	4	0.74 (0.21-2.57)
Anxiety/depression							
No	96	93	1.00	32	1.00	61	1.00
Yes	4	7	1.81 (0.51-6.38)	2	1.50 (0.26-8.58)	5	1.97 (0.51-7.61)

Abbreviations: CI, confidence interval; OR, crude odds ratio; TM, torus mandibularis; TMD, temporomandibular dysfunction; TP, torus palatinus.

*Statistically significant ($P < .05$).

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to 18.83; $P < .05$) showed an increased risk for the presence of TM (Fig 3).

Discussion

The authors' assumption was that subjects with an oral torus would exhibit a greater prevalence of tooth attrition and TMD, which have been linked with bruxism.[23-25,30-33] They also expected to find associations between oral tori and treatment with pharmacologic agents known for their bone-stimulating properties, such as antihypertension medications.[34-36] These investigations examined dental factors, TMD, and systemic factors, including treated hypertension,[36,34] treated hypothyroidism,[37-40] smoking,[41-43] periodontal disease,[44] treated diabetes mellitus,[45,46] penicillin allergy,[47-49] and treated anxiety/depression.[50-52] Research has linked each of these systemic factors with alterations in bone metabolism.[12,36-54] Other factors studied included age, gender, and respiratory problems (asthma and obstructive sleep apnea).

Although numerous studies have observed a link between oral tori and bruxism,[4,12-17] few studies have shown an association between oral tori and TMD.[16,17] Bruxism, the grinding and clenching of teeth, is a frequently cited contributory factor for the development of tooth attrition[23-25,55] and TMD.[30-32] Tooth attrition has also been found to have some predictive value for differentiating subjects with TMD from controls.[33,56,57] A case-control study that showed an increased prevalence of TM in subjects with TMD[16] did so by controlling for age, gender, and the presence of bruxism. Another case-control study showed a higher prevalence of TM in subjects with TMD,[17] but did not calculate the AORs or control for factors other than age and gender. The present study showed strong

Characteristic	Cases (n= 100)	Controls (n= 100)	AOR	95% CI	P value
TMD	44	14	5.22	2.32-11.77	<.01
Smoker	7	8	0.43	0.10-1.93	.27
Respiratory problem	9	4	2.63	0.54-12.77	.23
Periodontal disease	36	43	0.82	0.38-1.77	.61
Penicillin allergy	8	5	3.35	0.82-13.68	.09
Hypothyroidism	8	3	1.72	0.36-8.20	.50
Hypertension	23	21	2.29	0.83-6.33	.11
Gender	41	51	0.83	0.41-1.71	.62
Diabetes mellitus	5	8	0.46	0.094-2.22	.33
Attrition	59	23	10.51	4.46-24.78	<.01
Anxiety/depression	7	4	1.01	0.22-4.70	.99

Abbreviations: TMD, temporomandibular dysfunction; AOR, adjusted odds ratio; CI, confidence interval.

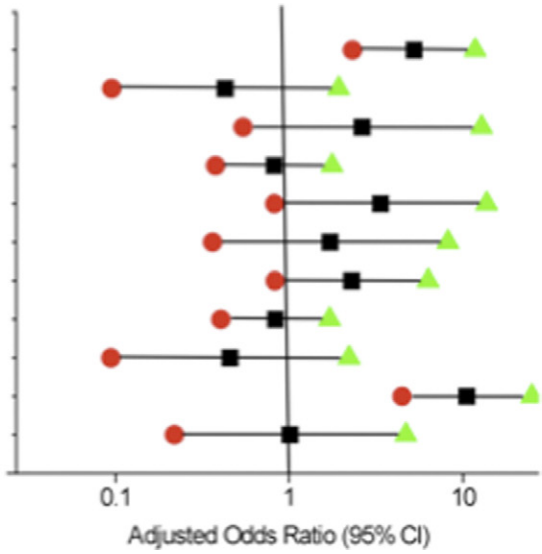

FIGURE 1. Summary and forest plot for associations between the presence of any form of torus (torus palatinus and/or torus mandibularis) and subjects' characteristics. AOR, adjusted odds ratio; CI, confidence interval; TMD, temporomandibular dysfunction.

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associations between the presence of oral tori (TP and/or TM) and tooth attrition and TMD. These findings indirectly indicate that individuals with bruxism, which is known to cause tooth attrition[23-25] and is implicated in the development of TMD,[30-32,55] are more likely to develop oral tori. The present study is the first to identify statistically significant associations between oral tori and tooth attrition and between oral tori and TMD while controlling for numerous dental and systemic factors. These findings are significant in that they show a link between local mechanical stresses and ectopic bone formation in the oral cavity.

Human bone metabolism is influenced by various cells produced in the bone marrow, including human mesenchymal stem cells, osteoblasts, osteoclasts, stromal cells, and adipocytes. In chronic diseases, such as osteopenia and osteoporosis, the balance between these cell types can be shifted to favor an overall

Characteristic	Cases (n= 34)	Controls (n= 100)	AOR	95% CI	P value
TMD	15	14	4.14	1.21-14.21	<.05
Smoker	2	8	0.15	0.01-2.55	.19
Respiratory problem	2	4	0.67	0.04-11.34	.78
Periodontal disease	11	43	0.59	0.16-2.21	.43
Penicillin allergy	1	5	0.89	0.07-12.18	.93
Hypothyroidism	5	3	6.54	0.81-52.63	.08
Hypertension	9	21	6.64	1.31-33.57	<.05
Gender	11	51	0.40	0.13-1.30	.13
Diabetes mellitus	1	8	0.14	0.01-2.38	.17
Attrition	21	23	38.18	7.20-202.41	<.01
Anxiety/depression	2	4	0.76	0.07-8.22	.82

Abbreviations: TMD, temporomandibular dysfunction; AOR, adjusted odds ratio; CI, confidence interval.

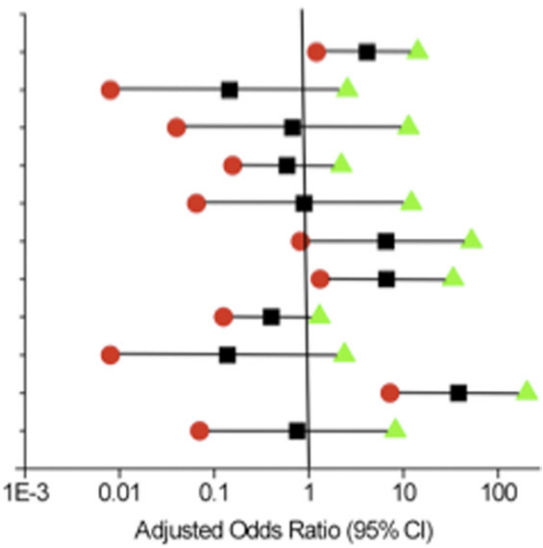

FIGURE 2. Summary and forest plot for associations between the presence of a torus palatinus and subjects' characteristics. AOR, adjusted odds ratio; CI, confidence interval; TMD, temporomandibular dysfunction.

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Characteristic	Cases (n=66)	Controls (n=100)	AOR	95% CI	P value
TMD	29	14	5.77	2.38-13.98	<.01
Smoker	5	8	0.35	0.07-1.82	.21
Respiratory problem	7	4	3.75	0.76-18.42	.10
Periodontal disease	25	43	0.97	0.42-2.23	.93
Penicillin allergy	7	5	4.45	1.05-18.83	<.05
Hypothyroidism	3	3	1.01	0.16-6.52	.99
Hypertension	14	21	2.35	0.78-7.08	.13
Gender	30	51	0.97	0.44-2.16	.94
Diabetes mellitus	4	8	0.42	0.08-2.22	.30
Attrition	38	23	6.70	2.78-16.14	<.01
Anxiety/depression	5	4	1.18	0.23-5.96	.84

Abbreviations: TMD, temporomandibular dysfunction; AOR, adjusted odds ratio; CI, confidence interval.

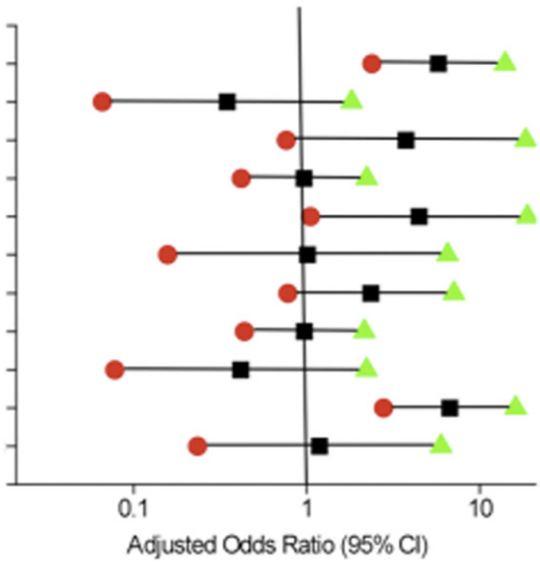

FIGURE 3. Summary and forest plot for associations between the presence of a torus mandibularis and subjects' characteristics. AOR, adjusted odds ratio; CI, confidence interval; TMD, temporomandibular dysfunction.

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catabolic state in bone.[58-60] The sympathetic nervous system innervates bone tissue, and it has been shown that its activity inhibits bone formation.[61] Accordingly, drugs that inhibit the activity of the sympathetic nervous system, such as antihypertension medications, have been shown to counteract this catabolic state and increase bone mineral density (BMD) and bone formation.[34-36,62] Furthermore, it has been shown that subjects with a greater overall BMD are more likely to have an oral torus.[54] The present study is the first to observe such an association between treated hypertension and the presence of an oral torus. These findings may explain the observed association between subjects with treated hypertension and the presence of a TP.

The thyroid gland and its hormones, key components of the endocrine system, strongly affect bone metabolism.[37-40,63,64] In subjects with hyperthyroidism, bone is characterized by high turnover, and this condition, if left untreated, gradually decreases BMD. This is because thyroid hormones stimulate bone-resorptive and bone-formative processes. Hyperthyroidism establishes an overall negative bone balance because of a more pronounced stimulation of bone resorption.[63] Conversely, hypothyroidism has been found to produce the opposite effect, whereby a lack of thyroid hormones results in stronger and thicker trabecular bone with more closely spaced trabeculae.[65] Hypothyroidism decreases the recruitment, maturation, and activity of bone cells, leading to decreased bone resorption and a net positive bone balance.[66] In the present study, a relation was found between hypothyroidism and the presence of a TP, although statistical significance was not achieved. Because of the tendency for a positive bone balance in hypothyroidism, it may be expected that subjects with this condition would be more likely to have an oral torus. The present observed association between hypothyroidism and the presence of a TP was interesting (close to significant, $P = .08$) in that it is the first such observation relating the endocrine system to ectopic oral bone formation.

Research in the field of osteoimmunology has suggested that a close interplay exists between the immune and skeletal systems.[47-49] Maintenance of skeletal integrity requires a balance between bone resorption and bone apposition.[67] This process of bone turnover is affected by multiple factors, including some that are secreted by the antigen-stimulated immune cells.[47] Subjects with excessive activation of the immune cells, as in arthritis, develop generalized and localized bone destruction, which can progress toward osteoporosis.[47,49] Conversely, low-grade hyperactivity of the immune system, as occurs in subjects with allergies, may actually stimulate bone formation.[68,69] It has been shown that, in addition to immunoglobulin E antibodies, cytokines such as interleukin-4, interleukin-13, and interferon-γ (IFN-γ) play important roles in penicillin allergy.[68] Recent research has shown that IFN-γ is necessary for the osteogenic differentiation of human mesenchymal stem cells in vitro and for the maintenance of BMD in vivo, suggesting a potential role of IFN-γ in bone formation in vivo.[69] It could thus be expected that subjects known to have increased levels of IFN-γ, as in

subjects with a penicillin allergy,[68] may be more likely to have greater bone accrual leading to the development of an oral torus. Associations between altered immune function and the appearance of oral exostoses and tori have been suggested, but they have not been corroborated by statistical evidence.[70] In the present study, the authors identified a statistically significant association between a penicillin allergy and the presence of TM. The present study is the first to provide statistical evidence for such an association between the immune system and ectopic bone formation in the oral environment.

Differences in the embryologic origins of the mandible and the maxilla result in distinct vascular and nerve supplies, which may account for the dissimilarities in how the bone in these areas responds to stress.[71,72] The well-known biological differences are the patterns of bone resorption that differ in the mandible and the maxilla, with alveolar ridge resorption occurring at a greater rate in the mandible despite a greater BMD.[73,74] Blood supply to the palate[75] and mandible[76] is regulated by sympathetic and parasympathetic efferent nerves, but dissimilarities in their responsiveness, and the resulting effects on bone metabolism, have not been thoroughly studied. Such differences may account for the present observed discrepancies in the response of maxillary bone (as with TP) and mandibular bone (as with TM) to antihypertension medications, low-grade immune system hyperactivity, and local mechanical stresses. Further research on the vascular and nerve supplies to the maxilla and the mandible is necessary to elucidate the nature of these differences.

A limitation of this study was that the retrospective design did not allow the determination of a cause-effect relation between oral torus formation and the various factors studied. A smaller proportion of control subjects compared with case subjects also limited the study. Because of the study design, it was not possible to support evidence for TMD with imaging techniques, such as computed tomography or magnetic resonance imaging. Furthermore, the authors were unable to assess the duration of the subjects' treatment with medications because the electronic records did not always include this information. However, this shortcoming is inherent in the case-control study design, whereby the accuracy of subjects' medical records may be questioned. To strengthen the interpretive value of the present results, the authors set the exposure status to include not only medications but also smoking status, dental factors, and various medical conditions. For these reasons, the present findings will need to be confirmed by future large-scale prospective cohort studies, with larger sample sizes and a lower possibility of bias, allowing for cause-effect relations to be established.

This article provides clinical evidence showing significant associations between oral tori and various dental and systemic factors. The authors' intent was not to sway the debate on the etiology of oral tori, but rather to elucidate additional systemic and local environmental factors believed to contribute to the formation of oral tori. The authors found indirect support for the role of bruxism, with evidence of tooth attrition and patient reports, in the development of oral tori. The authors also found a strong association between the presence of TMD and the presence of oral tori. A significant association was observed between treated hypertension and the presence of TP. The authors identified a significant association between a penicillin allergy (low-grade hyperactivity of the immune system) and the presence of TM. Overall, this work has identified relations between ectopic oral bone formation and local mechanical factors, the sympathetic nervous system, and the immune system. However, additional observational studies and controlled trials are needed to confirm these potentially important findings.

Future research may involve a broader assessment of systemic influences on the formation of oral tori. Studies may also be undertaken to investigate the effects of directed mechanical stress application—simulating that produced during bruxism—on alveolar bone quality and quantity. The present study provides much needed information on the influences of dental and systemic factors on ectopic bone formation in the oral cavity. This information may help to identify, in genetically susceptible individuals, methods to enhance bone quality for dental implant placement and/or alternatives to invasive surgical alveolar ridge augmentation procedures.

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