Torus Palatinus: A New Anatomical Correlation with Bone Density in Postmenopausal Women

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The observation that subjects who have a striking oral exostosis, called torus palatinus, also tended to have normal or high bone densities prompted us to examine an unselected population referred for bone density assessment for a possible correlation with torus palatinus. Subjects referred from community physicians had a visual examination of the open mouth to estimate the size of any torus palatinus (0 for none/trace to 5 for very large) before undergoing a bone density measurement by dual energy x-ray absortiometry. Bone density T- and z-scores were correlated with the size of each subject's torus palatinus. Torus size groups were also correlated with other variables affecting bone density. About 20% of 370 postmenopausal female subjects, >90% Caucasian, had a moderate to large torus palatinus. Regression correlations for torus size were modest, but significantly related to T- and z-scores of lumbar vertebrae and left hip (P < 0.01 for each). Differences due to medication, body mass index, smoking, parity, and several other factors that affect bone density did not diminish the relation to torus size. This study shows a small, but significant, positive relation for postmenopausal, Caucasian women between bone mineral density and torus size after controlling for several variables known to affect bone density were examined. Torus prominence, in association with other factors, can be considered in decisions for testing bone density in otherwise normal postmenopausal women. (J Clin Endocrinol Metab 88: 2081–2086, 2003)

TORUS PALATINUS IS A bony prominence at the middle of the hard palate (1, 2). The size varies from barely discernible to very large, from flat to lobular. This and other oral exostoses (torus mandibularis and torus maxillaris) are not a disease or a sign of disease, but, if large, may be a problem in the construction and wearing of dentures. These oral exostoses are usually composed of mature dense cancellous bone with a rim of cortical bone of variable thickness (1, 2). Occasional minimal osteoblastic activity or even hemopoietic marrow can be seen (2).

Bone density determinations are commonly sought to diagnose and follow patients with osteoporosis, a disease of low bone mass and increased risk for bone fracture and its consequences. Although there are biochemical correlates of bone loss and gain and a variety of techniques for bone mass measurements, the current gold standard is dual x-ray absorptiometry (DEXA). Although it is clear that the majority of the observed variance in peak adult bone mass is genetically inherited (3), the genes responsible for controlling skeletal mass are largely unknown. Recently two families with high bone mass have been found to have a unique gene product linked to the gene for low-density lipoprotein receptor-related protein 5 (LRP5) (4, 5). In these families an amino acid substitution resulted in a mutated gene on chromosome 11q12–13 that produced a gain of function affecting bone deposition (3, 4).

High bone mass is an uncommon finding (6) that, in most cases, is associated with a reduced risk of skeletal fracture. In the course of investigating one family with high bone mass

associated with a gene mutation (4) and also in the clinical practice of one of us (J.L.B.), many patients with a prominent torus palatinus were noted to have normal or high bone densities. We postulated that the presence and especially the size of a torus palatinus may be correlated with increased bone mineral density (BMD), and we undertook the following study to test this hypothesis in an unselected, unrelated, community population.

Subjects and Methods

All subjects were referred to the Danbury Hospital Nuclear Medicine Department by their physicians for bone densitometry determinations by DEXA using a Lunar-DPX-L (Lunar Corp., Chicago, IL). Imaging of the second through fourth lumbar vertebrae and left hip was performed by a trained technician (J.E.H.) who administered a questionnaire intended to elicit osteoporosis risk factors. The patient was informed of the investigation and volunteered to undergo visual inspection of the oral cavity. The palate was not palpated. An estimated palatal torus size grade (0 indicating none/trace to 5 indicating very large), based on comparison with a pictorial series of torus sizes, was assigned without knowledge of the DEXA outcome. A second torus size grader confirmed the size assignment in the initial study phase and thereafter about 10% of the assignments. Rarely was an assigned size altered, and then only by one grade. Agreement by two observers ensured reasonable reproducibility of size assignments despite the qualitative nature of this method. A torus palatinus judged to be grade 1 (small) and one graded 5 (large) are shown in Fig. 1. Bone density results are expressed as the deviation from the reference means for sex- and race-matched individuals in the general population. The T-scores compare subjects with young adults and the z-scores compare subjects with reference values for age-, sex-, and race-matched subjects. This study, including the form of consent, was approved by the Danbury Hospital institutional review board.

Statistical methods

Pearson product-moment correlations (7, 8) were computed to examine a linear relationship between torus, using all graded measures of
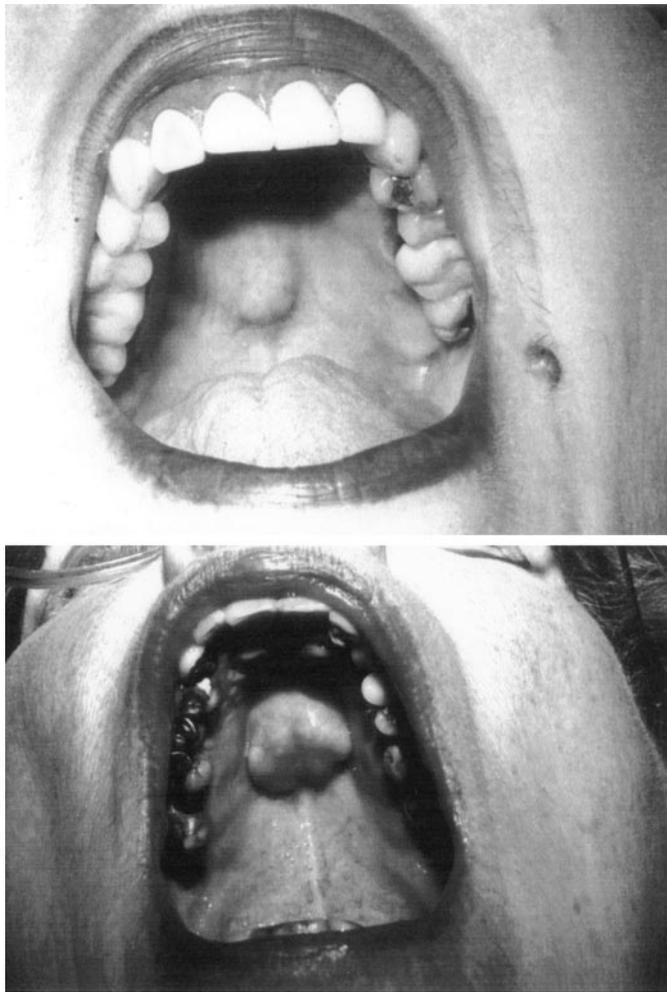
FIG. 1. *Top*, A small torus palatinus. *Bottom*, A large torus palatinus.

torus sizes (0 to 5) and the T- and z-scores of the second to fourth lumbar vertebrae and left hip.

To eliminate other possible confounding variables, partial correlations (9) were found between torus size and the second to fourth lumbar vertebrae and left hip scores, and tests of differences among the torus measurements were conducted for the available data. Torus measurements were categorized into three torus size grade groups to enlarge group size for greater statistical emphasis: absent/trace (size, <1), small/moderate (size, 1–2), and large (size, ≥3). Preliminary analysis showed no significant differences between a numerical size group and its neighbor within the combined categories. ANOVA (5) was used to determine whether bone density differences among the three torus size groups could be attributed to the continuous variables. χ^2 analyses (7, 9) were used to test for independence of torus and the categorical variables (Table 1). Minitab and SPSS (SPSS, Inc., Chicago, IL) were used for all statistical analyses (10, 11).

Results

Complete datasets were available for a total of 469 subjects who were community-based, nonselective, overwhelmingly Caucasian (>90%), and postmenopausal (82% of 452 females; age range, 16–89 yr). Correlation of torus sizes with bone density using all available data points for the total population was highly significant ($P < 0.01$). Findings only in the Caucasian postmenopausal women form the basis for further analyses of the relationship between torus palatinus and

TABLE 1. Characteristics of postmenopausal sample

	Torus size			*P*
	None/trace	Moderate	Large	
Total no.	276	46	42	
Age				
Mean	60.01	57.74	55.50	0.138^a
Range	24–82	46–84	39–89	
Smokers[b]				
Yes	44	3	8	
No	230	43	34	0.189^c
≥1 yr HRT				
Yes	87	12	17	
No	174	30	22	0.332^c
BMI				
Mean	27.64	26.44	27.29	0.431^a
Range	18–58	18–45	20–47	
Parity				
Mean	2.81	2.73	2.08	0.073^a
Range	0–13	0–8	0–4	
Thyroid medication				
No	227	38	39	
Yes	49	7	3	0.219^c
Steroid medication				
No	239	39	40	
Yes	39	7	2	0.228^c
Age at menopause				
Mean	47.81	49.09	47.93	0.371^a
Range	20–70	24–57	30–55	
Fractures				
No	240	38	34	
Hip/spine	20	3	2	0.899^c
All fractures	37	8	4	0.643^c

[a] *P* values based on ANOVA.
[b] Nonsmokers include those who have quit for 5 or more years.
[c] *P* values on χ^2 test.

bone density. The number of males, premenopausal women, and African-American subjects were too few for meaningful separate analyses. There were 279 postmenopausal Caucasian women with no/trace discernible torus, 25 with grade 1, 21 with grade 2, 20 with grade 3, 13 with grade 4, and 10 with grade 5. Mandibular tori and other oral exostoses were only rarely seen. Although the prevalence of oral exostoses may increase with age (1), our subjects who were aware of prominent tori reported that these were present lifelong and had not changed in size, number, or appearance. We found that many subjects were unaware of even a large torus until their fifties or older.

For postmenopausal women the correlation between torus size and the T-score for lumber vertebra 2–4 was 0.264, and that for T-score for hip was 0.211 (both $P < 0.01$). Scatterplots for T-score for lumber vertebra 2–4 and T-score for hip compared with torus sizes 0–5 including all postmenopausal female subjects are shown in Fig. 2. Correlations were similar between torus size and z-scores and were 0.223 for lumbar 2–4 and 0.205 for left hip (both $P < 0.01$; not shown). We also combined torus sizes into three categories [absent/trace (size, <1), small/moderate (size, 1–2), and large (size, ≥3)] to facilitate further analysis. Box plots of T-scores (Fig. 3) illustrate this correlation. When these findings were controlled for differences in factors that may affect bone mineral density (Table 1), the partial correlations for T-scores were 0.251 and 0.227 (both $P < 0.01$) for lumbar vertebra 2–4 and hip, respectively. Partial correlations
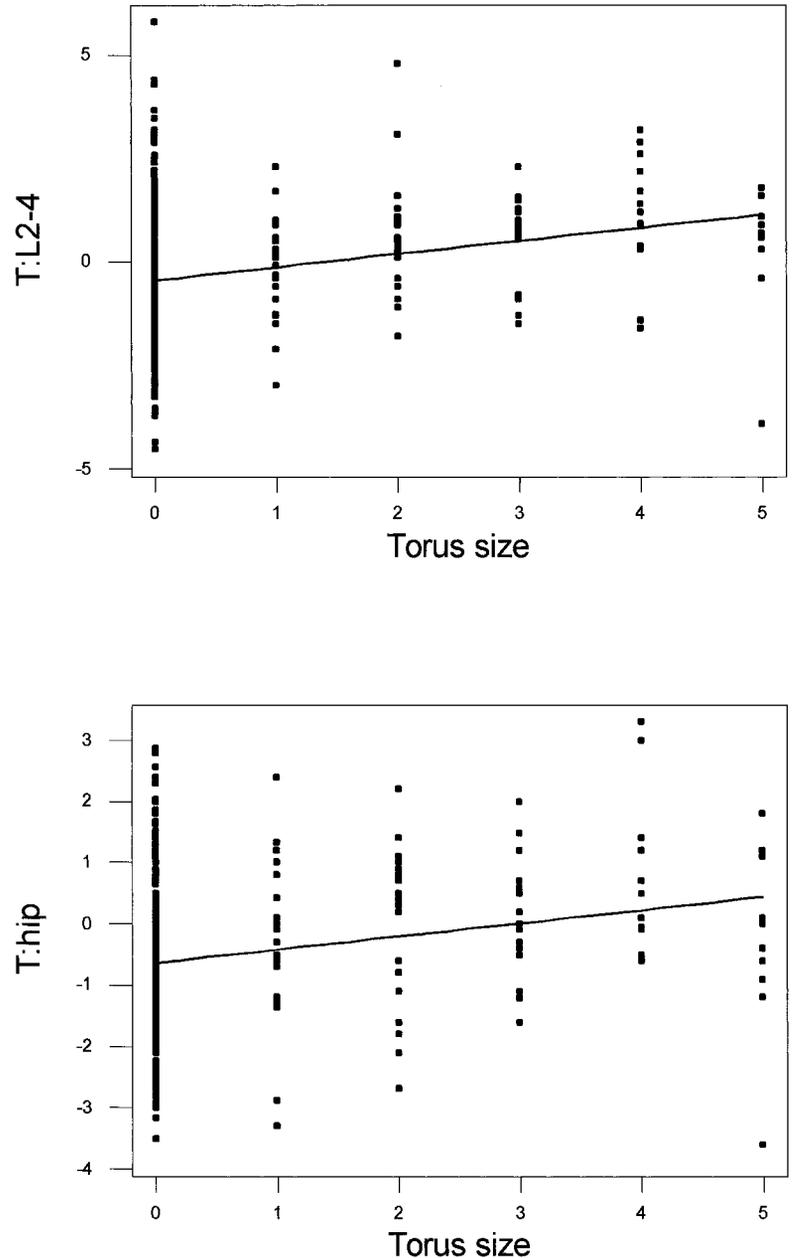
F<small>IG</small>. 2. Comparison of lumbar and hip bone densities of subjects with younger women (T-scores with least squares regression line). *Upper panel*, Plot of torus palatinus size on T-scores for lumbar vertebra 2–4 (r = 0.264 for the mean; $P < 0.01$). *Lower panel*, Torus size on T-scores for hip (r = 0.211; $P < 0.01$).

for z-scores were 0.227 for lumbar vertebra 2–4 and 0.197 for hip (both $P < 0.01$).

ANOVAs for bone density variables using the three size groups were highly significant ($P < 0.01$) T-scores (Fig. 4) and also for z-scores (not shown) for our postmenopausal subjects.

Examination of other factors associated with or affecting BMD (Table 1) showed none of these to be significantly related to torus size. Only lower parity shows a trend ($P = 0.073$) associated with increasing size of torus. Torus sizes were similarly prevalent among those with and without diabetes, a condition that may be associated with decreased bone density. Comparison of torus size in the one-third of postmenopausal women in our population who never received hormone replacement therapy (HRT) or who were treated for less than 1 yr also showed a positive correlation between torus size and

bone density. The proportions of subjects in the three torus categories of non-HRT-treated women (torus sizes: absent/ trace, 77%, small/moderate, 13%; large, 10%) were virtually identical with those in HRT-treated subjects (75%, 10%, and 15%, respectively). Although not reaching statistical significance, we found that estrogen-deficient subjects, smokers, and those receiving chronic steroid therapy also showed a positive relationship between torus size and BMD.

Discussion

Our observations strongly suggest that postmenopausal Caucasian women with large torus palatinus have a higher mean bone density than their peers as well as a higher bone density than much younger women. A similar association has previously been suggested. Hjertstedt *et al.* (12) reported

Boxplots of T: hip by Torus Size

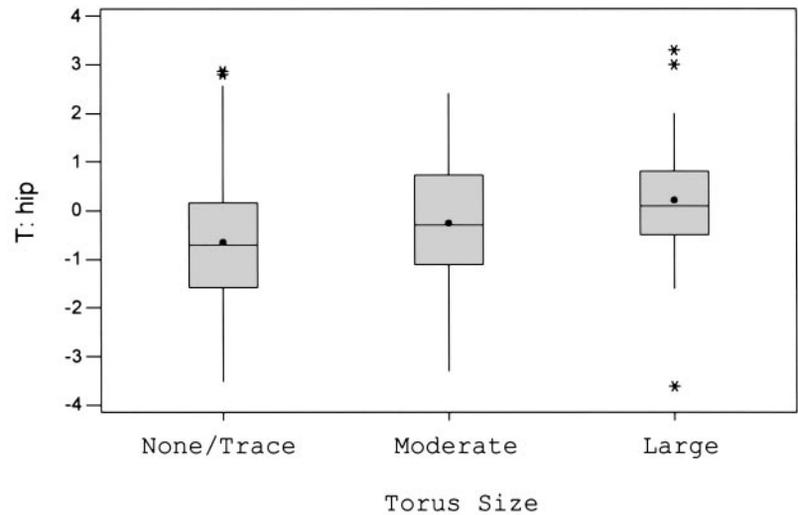### (means are indicated by solid circles)

FIG. 3. Box plots for T-scores among torus size groups. The *horizontal line* in the *box center* is the median score; the *vertical lines* show lower and upper quartiles of the T-scores. The *solid dot* indicates the mean for each torus group. Each *asterisk* denotes an outlier. *Upper panel*, T-scores for hip. *Lower panel*, T-scores for lumbar vertebra 2–4.

Boxplots of T: L2-4 by Torus Size
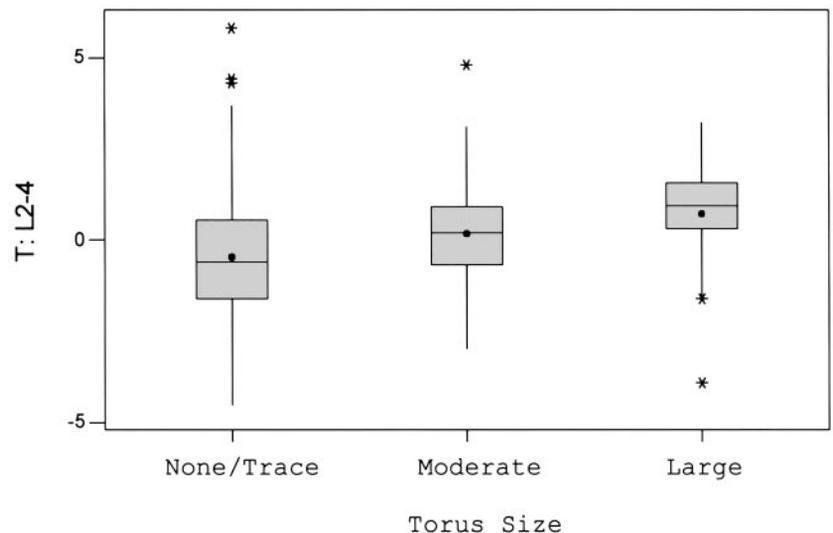
in 2001 on the relationship of mandibular and palatal tori to BMD among 101 females and 129 males over 70 yr of age. Although most correlations were lower than the present study, there was a significant relationship among females between the presence of mandibular tori with BMD at the femoral neck ($P = 0.03$) and trochanter ($P = 0.04$). There was no significant correlation for male subjects. Palatal tori showed a significant relationship ($P = 0.04$ for proximal radius and $P = 0.01$ for distal radius) only for male and females combined, but not for females separately. The larger numbers of subjects in our study likely account for the stronger correlations we observed. We suspect the association of bone density and large oral exostoses probably also applies to premenopausal women, males, and non-Caucasians, al-

though our sample has too few subjects in these categories to confirm this. Yoda *et al.* (13) reported in an abstract that 9 elderly females with palatal tori had higher BMD z-scores at the femoral neck, but not lumbar spine and radius compared with 24 females without palatal tori. No significant association was found in males.

In the present study both estrogen-replaced women and those not taking HRT have a positive correlation of torus size with bone density of the lower spine and hip, suggesting that this is not an artifact of antiresorptive therapy.

Kolas *et al.* (14) reported the prevalence of torus palatinus and torus mandibularis in 2478 dental patients (85% Caucasian) as 14.7% in males and 26.73% in females (24% for females in our study). A higher prevalence of oral exostoses
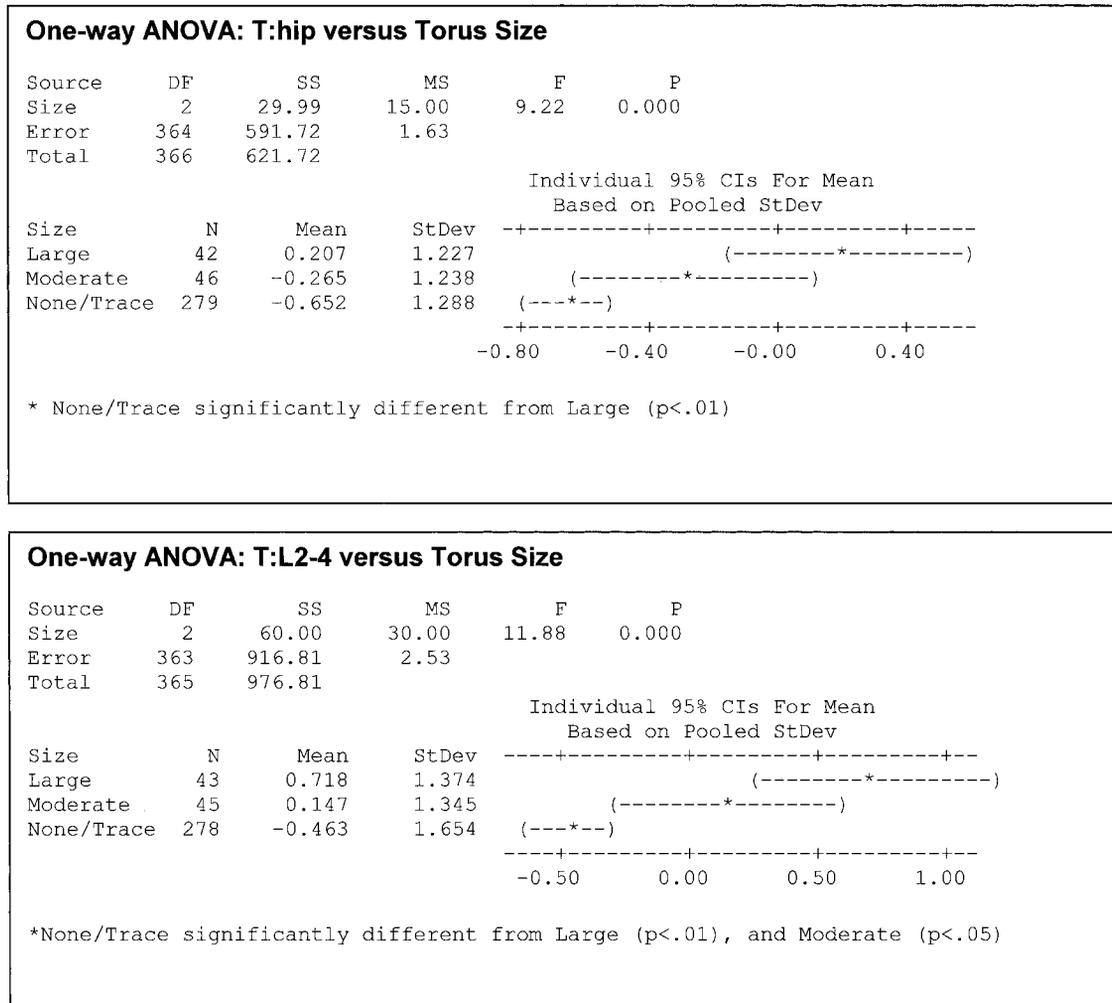
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One-way ANOVA: T:hip versus Torus Size

Source      DF         SS        MS         F        P
Size         2      29.99     15.00      9.22    0.000
Error      364     591.72      1.63
Total      366     621.72
                                    Individual 95% CIs For Mean
                                      Based on Pooled StDev
Size            N      Mean     StDev  -+---------+---------+---------+-----
Large          42     0.207     1.227                         (--------*---------)
Moderate       46    -0.265     1.238          (--------*---------)
None/Trace    279    -0.652     1.288   (---*--)
                                       -+---------+---------+---------+-----
                                     -0.80     -0.40     -0.00      0.40


* None/Trace significantly different from Large (p<.01)
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One-way ANOVA: T:L2-4 versus Torus Size

Source      DF         SS        MS         F        P
Size         2      60.00     30.00     11.88    0.000
Error      363     916.81      2.53
Total      365     976.81
                                    Individual 95% CIs For Mean
                                      Based on Pooled StDev
Size            N      Mean     StDev  ----+---------+---------+---------+--
Large          43     0.718     1.374                       (--------*---------)
Moderate       45     0.147     1.345             (--------*--------)
None/Trace    278    -0.463     1.654   (---*--)
                                       ----+---------+---------+---------+--
                                        -0.50      0.00      0.50      1.00


*None/Trace significantly different from Large (p<.01), and Moderate (p<.05)
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FIG. 4. ANOVA tests of three torus size groups with T-scores. *Upper panel*, T-scores for hip; *lower panel*, T-scores for lumbar vertebra 2–4.

was reported for other racial groups, including Peruvians, Native Americans, Japanese, Thais, and Eskimos (12, 13). The occurrence increases with age (1, 12, 13), achieving a plateau by the third decade, a period when peak bone mass is usually achieved. In the present study subjects reported no size changes with aging. Suzuki and Sakai (15) reported an autosomal dominant pattern of inheritance in 150 families in Japan and found that the more marked the development of torus palatinus in the parents the higher the frequency in their children.

Identification of women at-risk for osteoporosis has become a major issue in health care due in part to the significant cost of testing and to low test specificity (16). Guidelines for cost-effective screening to identify individuals with osteoporosis were recently reviewed by Cadarette *et al.* (16) and included older age, lower body weight, and absence of estrogen therapy. Personal or family history of fracture, cigarette use, race, and rheumatoid arthritis were noted as additional risk factors. Clinicians may also weigh other considerations in deciding to test for the presence of osteoporosis, including loss of height, chronic steroid or ʟ-thyroxine therapy, the presence of type I diabetes, hypogonadism, immobility, vitamin D deficiency, or hyperparathyroidism. In daily practice there is increasing pressure to have bone density measured even when none or few of the above criteria are present.

In individual subjects there are no clear signs or symptoms that indicate the presence of normal or high bone density [with the exception of the unique family with very large, lobulated palatal and other oral exostoses who have a mutation conveying unusually high bone density (4) or in specific, rare conditions (6)]. Epidemiological studies have shown that mean bone densities are higher in people who are obese, in younger subjects, and in African-Americans. To these can now be added the easily noted presence of torus palatinus and perhaps torus mandibularis (12), especially if these prominences are large. However, even this finding must be judged in conjunction with all other risk factors in individual assessments.

Our findings of suggestive associations between both decreased parity as well as younger mean age (Table 1) among those with the largest torus palatinus (and increased bone density) are intriguing and need further study.

The precise mechanism for the positive relation of torus size to bone density is unknown. Indeed, polymorphism in the LRP5 gene (3) (or other genes not yet identified) may signal a process that enhances bone deposition (4), and fur-

ther molecular genetic studies could target subjects and their families with large torus.

The relation of torus size to bone density needs further confirmation, including assessment of males, premenopausal women, and families with inherited large tori. Clearly several hundred subjects are required for such studies in view of the small r values noted in this and other reports (12, 13). More precise quantification of torus size or shape may be desirable, but is not expected to significantly alter the relationship reported. Osteoarthritic changes in aging vertebrae can confound DEXA interpretation of bone density, resulting in artifactually higher BMD values. Although the present study could not estimate the degree of this effect, review of the DEXA images showed similar lumbar osteoarthritic changes in all torus groups. A study of torus palatinus and other large oral exostoses and bone density in subjects in the third and fourth decades of life could minimize this potential interference.

Examination of the hard palate should be considered a routine part of the physical examination in postmenopausal women and, in fact, in all patients in conjunction with bone density measurement.

Acknowledgments

References

1. **Jainkittivong A, Langlais RP** 2000 Buccal and palatal exostoses: Prevalence and concurrence with tori. Oral Surg Oral Path 90:48
2. **Gnepp DR** 2001 Diagnostic surgical pathology of the head and neck. Philadelphia: Saunders; 159–161
3. **Baudoin C, Cohen-Solal ME, Beaudreuil J, Vernejoul MC** 2002 Genetic and environmental factors affect bone density variances of families of men and women with osteoporosis. J Clin Endocrinol Metab 87:2053–2059
4. **Boyden LM, Mao J, Belsky J, Mitzner L, Farhi A, Mitnick MA, Dianqilng W, Insogna K, Lifton, RP** 2002 A syndrome featuring high bone density caused by a mutation in *LRP5*, a component of the Wnt signaling pathway. N Engl J Med 346:1513–1520
5. **Little RD, Carulli JP, Del Mastro RG, Dupuis J, Osborne M, Folz C, Manning SP, Swain PM, Zhao S-C, Eustace B, Lappe MM, Spitzer L, Zweier S, Braunschweiger K, Benchekroun Y, Hu X, Adair R, Chee L, FitzGerald MG, Tulig C, Caruso A, Tzellas N, Bawa A, Franklin B, McGuire S, Nogues X, Gong G, Allen KM, Anisowicz A, Morales AJ, Lomedico PT, Recker SM, Van Eerdewegh P, Recker RR, Johnson ML A** 2002 Mutation in the LDL receptor-related protein 5 gene results in the autosomal dominant high-bone-mass trait. Am J Hum Genet 70:11–19
6. **Johnson ML, Picconi BS, Recker RR** 2002 The gene for high bone mass. Endocrinologist 12:445–453
7. **Neter J, Kutner M, Nachtsheim C, Wasserman W** 1996 Applied linear statistical models, chapt 16, 4th Ed. Chicago: Irwin
8. **Fisher L, VanBelle G** 1993 Biostatistics, chapt 7. New York: Wiley & Sons
9. **Zar J** 1996 Biostatistical analysis, chapt 19. Totowa: Prentice-Hall
10. **Minitab, Inc.** 2000 Minitab Release 13. State College, PA: Minitab, Inc.
11. **SPSS**® 9.0 for Windows, SPSS, Inc., 1999.
12. **Hjertstedt J, Burns EA, Fleming R, Raff H, Rudman I, Duthie EH, Wilson CR** 2001 Mandibular and palatal tori, bone mineral density, and salivary cortisol in community-dwelling elderly men and women. J Geront 56A:M731–M735
13. **Yoda T, Yamaguchi M, Amano H, Orimo H, Hosoi T** 2002 Association of oral exostosis with higher bone mineral density of elderly women [Abstract]. J Bone Miner Res 17(Suppl):S486
14. **Kolas S, Halperin V, Jerreris K, Huddleston S, Robinson HBG** 1953 The occurrence of torus palatinus and torus mandibularis in 2,478 dental patients. Oral Surg 6:1134–1141
15. **Suzuki M, Saki T** 1960 A familial study of torus palatinus and torus mandibularis. Am J Phys Anthropol 18:263–272
16. **Cadarette SM, Jaglal SB, Kreiger N, McIsaac WJ, Darlington GA, Tu JV** 2001 Evaluation of decision rules for referring women for bone densitometry by dual-energy x-ray absorptometry. JAMA 288:57–63