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Research Article

A Hypothesis for Tori Growth and Enlargement at Specific Locations: A Review of the Literature and Case Studies

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Abstract

The etiology and location of intra oral bony growths termed tori remains unclear and is considered a nonpathological exostoses. A clinical study of three patients having tori with evidence of parafunction for an extended period of time was conducted by (JOG). Diagnostic casts, clinical observations and patient's history were used to monitor the enlargement of the tori at various intervals. Observations were that there was a significant relationship between the presence of both maxillary and mandibular tori to hyperfunction and parafunctional activities. The common occurrence of tori in areas of greatest stress concentration, such as the hard palate's midline suture and the lingual bicuspid/cuspid region of the mandible suggests that bone apposition may also be due to a piezoelectric effect which stimulates bone growth in these preferential locations. A hypothesis is presented based on established biomedical engineering mechanisms that stress concentration causes the formation and enlargement of tori.

Keywords: Stress Concentration; Piezoelectricity; Parafunction; Collagen; Electric Potentials; Biocorrosive/Abfractions

Introduction

An awareness and acceptance of the bioengineering mechanisms involved during the dynamics of hyperfunction and parafunctional activities such as clenching and bruxism with their resultant effect on bone will shed light into the etiology of tori and to their increase in size at preferential regions. This hypothesis may further assist the practitioners' understanding and treatment of some of the dental challenges that occur during prosthetic replacements such as partial and full dentures, as well as implants.

A review of the existing literature indicates that the etiology of tori is not firmly established. According to the Shafer., *et al.* textbook, "numerous theories have been suggested, but a plausible and thoroughly convincing explanation for these common oral lesions is still lacking" [1]. The author (JOG) has recorded case studies over an extended period of time to demonstrate that tori, both mandibular and maxillary, increase in size. Their increase in size which varies with time has a strong relationship to hyperfunction and parafunction, which occurs in regions of stress concentration within the bone. The presence of tori were most common at the maxillary median suture line and on the lingual surface of the mandible in the region of the bicuspids. Little clinical significance has been attached to these benign lesions, since they have never been reported as becoming malignant. Unless tori become a problem in the fabrication of partial dentures, full dentures or implants, removal is seldom warranted; however, they occasionally are removed if they interfere with speech. This manuscript gives a brief history of tori formation and present digital photographs demonstrating the reactivity of bone in areas of stress concentration in three typical cases. Biomechanical, biochemical and bioelectrical factors should be considered in the genesis of tori as well as exostoses.

Historical Overview

One of the earliest investigators into the etiology of tori formation was in 1933 by GP Matthews who found among Icelanders and Eskimos that tori were associated with powerful masticatory musculature with teeth showing marked occlusal wear. He found that whenever the jaw bones were dense and massive, these tori were small or absent. The greater mass and density of their bones would resist flexural forces thus accounting for the lack of tori. In addition, Matthews observed that wherever occlusal facets occurred indicating powerful mastication and forces directed toward the median plane, palatal tori were more frequent. Furthermore, he noted that whenever the maxillary and mandibular incisors occluded in an edge-to-edge contact, the mandibular tori occurred more often. He also stated that tori, brought about by physiological processes resulting from functional demands, are useful acquired manifestations, and not pathological lesions [2].

Publications are replete with definitions and descriptions of tori starting with Von Carabelli's "Anatomie des Mundes" which was published in 1842 [3]. Notwithstanding, after numerous investigations, an adequate explanation of the etiology of tori has remained elusive. At this date, the most generally accepted etiological factors in the formation of these exostoses has been based on genetics and hyperfunctional influences. In 1985, Rezai., et al. Jackson and Salamat published a review of the literature on torus palatinus [4]. Hooten [5], Hrdlicka [6], and Luzardo [7] in separate publications, associated the presence of tori with hyperfunction. Schreiner in contradistinction, rejected all connections to function, citing the presence of torus palatinus in the palates of newborns without mechanical stimuli [8]. The authors contend that the conclusion by Schreiner is questionable since the advent of the ultrasonography now reveals that fetuses have been shown to suck their thumb in utero. Action of thumb sucking could possibly stimulate bone apposition during this period of very active growth. Syphilis infection has been suggested by Chassaignac [9] while Lachman [10] purported that rickets was the primary cause of tori formation. Thoma [11] as well as Robbins and Cotram [12] supported the view that tori were developmental malfunctions of the jaws. Studies by Suzuki and Sakai [13], as well as Gould [14] have identified heredity as the most important factor associated with the occurrence of tori. Anthropological studies by Kupffer [15] and Fuerst [16] show the highest incidence of tori among peoples in the more densely populated northern hemisphere. Geographic origin appears to be a common finding among researchers such as Osima [17] who found that the Koreans ranked first followed by the Japanese [18] and Eskimos [7]. It is author's observation that those populations (Koreans and Japanese) having the largest incidence of tori are also those who masticate resistant foods. They are both especially fond of eating dried squid, which is a very tough and resistant food, requiring great force to masticate. Eskimos are also known to use their teeth as tools to soften hides of animals, such as seal skin. The resultant stress from chewing among these various ethnic groups would therefore become a factor in the genesis of tori. Climate and environmental conditions have also been suggested as being factors in the etiology of tori [19].

Tori are classified according to either size or shape. Miller and Roth described their size as either slight, moderate, or marked [19]. Matthews [2] suggested the most popular description of tori by designating them as either flat, spindle, nodular or lobular in shape. The distribution of tori among sexes has shown that females are more inclined to have tori. A number of researchers, Lachmann [10], Miller and Roth [20], Rivard [21], King and Moore [22] and Bhaskar [23] reported a female-to-male distribution ratio of two-to-one.

Materials and Methods

A study of three patients who had tori over an extended period of time was conducted by (JOG). Observations were made on their diagnostic casts at various intervals to determine the changes which occurred. The first case was provided to me by Enrico M Grippo, DDS who was a dentist for an oral surgeon having these tori who is now deceased.

Results

Typical cases are presented which demonstrate enlarged tori, as diagnostic casts will attest. A most dramatic case is shown by models dating back to 1939, of a male oral surgeon while a dental student, now deceased, who subsequently developed massive bilateral mandibular tori over the ensuing years. Composite series of casts show the growth and recurrence of bilateral mandibular tori from 1939 to 1990 (Figure 1). He was an admitted clencher and bruxer who never wore a bite guard. Presence of occlusal wear facets on the diagnostic casts indicates bruxism; as the facets enlarged, so did the tori. The initial diagnostic cast from 1939 shows the absence of tori and the lack of facets on the cuspids as well the bicuspids. In 1974 the cast depicts the development of tori mandibulari and the presence of wear facets on the both cuspids and the left first bicuspid. The lower right first bicuspid had an acrylic veneer crown, thus a different wear pattern may be noted. This cast demonstrated that the torus on the left side was larger than the one on the right. The larger torus on the left corresponds with the larger facets on the ipsilateral cuspid and first bicuspid. In 1986 it shows the enlarged bilateral lobular tori and correspondingly larger facets, as well as Class VI lesions. Both tori were removed in 1986 (see figure 2) and subsequently recurred in 1990, as depicted in that diagnostic cast.

Figure 1: *A composite picture from 1939 - 1990 of a dentist's dentition showing the progressive growth in (1974 and 1986) and recurrence in (1990) of the mandibular tori following their removal. Wear facets from bruxing are beginning to form on the lower anterior teeth in 1939 and enlarged during the ensuing years (1974 - 1990). Courtesy of Enrico M Grippo, DDS (Private practice in Bellows Falls, VT, now deceased).*

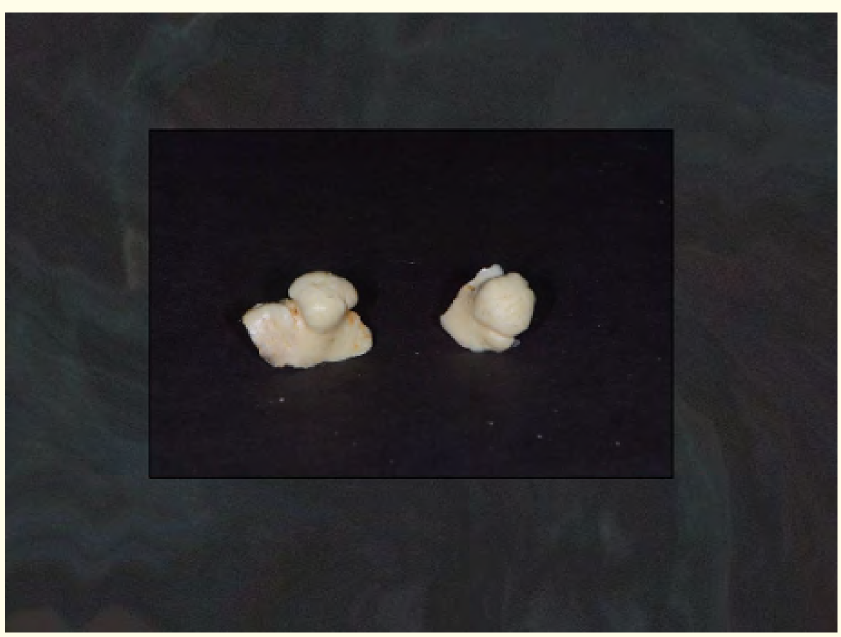

Figure 2: *Mandibular tori were removed in 1986 as depicted in figure 1. Note that they were perfectly cleaved from the mandible and were recurring in 1990 following their surgical removal. Courtesy of Lawrence Massucco, DDS (Private practice Bellows Falls, VT now deceased).*

In the composite photos of four diagnostic casts of figure 3, it will be noted that the torus palatinus enlarged over a 30 year period from 1987 - 2017. This 82 year old female patient was not only an admitted clencher, but in the past had taken estrogen as well as progesterone which may have possibly exacerbated the bone growth. She also had bilateral mandibular tori which had enlarged. Furthermore, there was history of tori in her family which genetically predisposed her to having the tori. The patient also had sleep apnea but refused to have the maxillary tori removed. This massive tori in 2017 could probably have been a factor in the cause of her sleep apnea.

Figure 4 demonstrates the growth of bi-mandibular tori for a period of 12 years from 1989-2001 in a male. Notice the enlargement of all of the class VI lesions on the incisal and occlusal surfaces indicating severe bruxing and the effects of an acidic biocorrodent. Tooth #30 had a gold crown placed during this period of time. This patient did not have any maxillary tori, however, did have numerous non-carious lesions termed biocorrosive/abfractions. The patient did wear a bite guard.

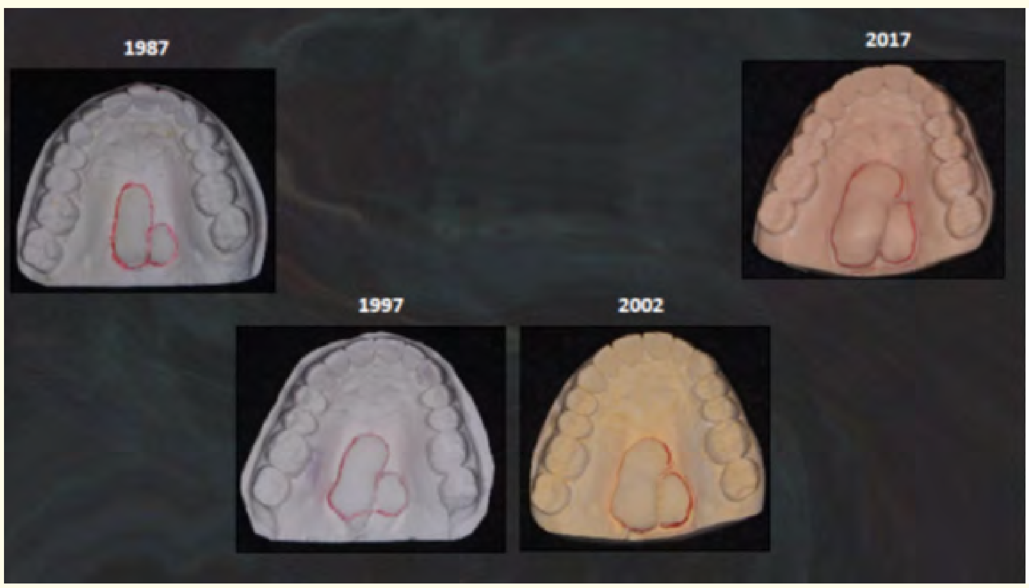

Figure 3: *A sequential enlargement of torus palatinus in an 82 year old female caused by stress from excessive loading over time.*

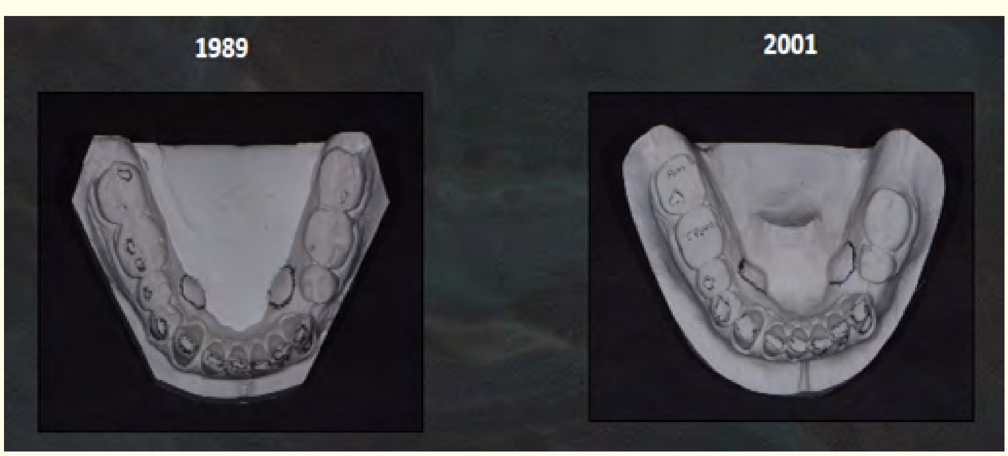

Figure 4: *Male patient, age 57 years with mandibular tori which have enlarged over 12 years. Numerous incisal and occlusal Class VI lesions marked with pencil markings are signs of bruxism and an acid biocorrodent.*

Figure 5 is frontal view of figure 4. Demonstrating the progressive effects over time of stress manifested as abfraction and a biocorrosive exogenous acid, simply referred to as biocorrosive/abfractions. The facial incisal and occlusal non-carious lesions in this patients is evidence of stress to his bone housing these teeth causing tori.

Discussion

In all three aforementioned cases appositional bone growth has occurred over a period of time. One can suggest from this data supported by Wolff's Law, that parafunction in addition to hyperfunction could be accepted as a co-factor in the etiology as well as enlargement of tori. In 1892, Julius Wolff recognized that bone had the capacity to reshape its configuration according to changes in mechanical stress [24]. Wolff stated that the bone elements, once formed, rearrange themselves into the direction of functional pressures and increase or decrease their mass to reflect the functional stress. In 1957, Fukada and Yasuda demonstrated that when bone is mechanically deformed a small electric current is generated relative to an unstressed area [25]. They attributed this piezoelectric effect to the crystalline structure of bone and that wherever bone is under compression a resultant negative charge evokes bone apposition; while on the opposite side, which is in tension and positively charged, bone resorption occurs. Bassett and Becker, working independently in 1962, were able to demonstrate that bone produced electrical potentials when deformed [26]. Their research indicated that the amplitude of the electrical potentials created in the stressed bone was dependent on both the rate and the magnitude of the deformation. Polarity was related to the direction of flexing. Areas under compression were electrically negative in relation to the other areas.

Figure 5: *Patient in figure 4 demonstrating the progressive effects of stress and biocorrosion termed biocorrosive/abfractions caused by stress from bruxing combined with biocorrosive exogenous acids creating facial, incisal and occlusal non-carious lesions.*

Further experimental studies by Fukada and Yasuda testing long bones were also conducted noting that when bone is placed under stress, regions under compression were concave and became negatively charged [27,28]. Conversely, regions under tension became convex and were positively charged. Bassett., et al. again supported this hypothesis and found that masses of new bone grew around negative electrodes implanted in the long bones of dogs [29]. They further suggested that the initial step is the deformation force which activates a number of piezoelectric transducers probably located at the collagen hydroxyapatite interface which then generate electrical potentials proportionate to the applied force. These potentials, in turn, stimulate the bone remodeling response thus altering the shape of the bone. Gianelly and Goldman's preeminent text "Biologic Basis for Orthodontics" summarizes in detail all of these aforementioned events [30]. It is suggested that for further information on the activity of bone the reader may refer to the "Bioelectric Perturbations of Bone" by Norton, Hanley and Turkewicz [31].

Hypothesis

The authors hypothesize that during the dynamics of clenching, bruxing and excessive masticatory force, flexure of the mandible occurs and various stresses become concentrated in the structurally weakest region of the mandible (Figure 1). Resultant stresses in the body of the mandible would therefore be greatest in the cuspid and bicuspid area where there is less mass. Flexure of the mandible was first reported by Jung [34] in 1952 and subsequently verified by others [35-44]. Radiologists whom the author (JOG) consulted have confirmed that most fractures of the body of the mandible occur in this region thus suggesting this area as being the weakest point of the body of the mandible. In this area, compression would occur on the lingual surface during hyper and parafunction, thus resulting in a negative charge which promotes bone apposition. The enlarged bone (tori) would then create a buttressing effect to the mandible. This premise, though not scientifically proven, is based on the bioengineering mechanism of Wolff's Law. Likewise, the weakest point of the maxilla would appear to be the median suture line of dentates where the stresses are concentrated in a similar manner as a physiologic response occurs in this region of increased stress by producing bone. As aptly expressed by Dubrul and Sicher, "Bone is a living calcified system of stress" [35]. A piezoelectric effect occurs in both of these areas of stress concentration which may promote the deposition of bone [25-29]. Biomechanical, biochemical and bioelectrical activity in the bone seems to occur in these regions of stress concentration. Heretofore, these activities have not been linked as co-factors in the formation of tori.

A controlled scientific study to reproduce and verify all of these events is a monumental task and a heroic challenge to researchers. The dynamics of interocclusal activity as well as its effects on teeth and bone are complex and have many variables, thus making it extremely difficult to study and quantify. In the meantime, the aforementioned explanation appears to be a sound and convincing hypothesis based on well-established bioengineering mechanisms. Bony outgrowths which occasionally occur in other regions of both the maxilla and mandible are referred to as exostoses. These types of exostoses appear to result from overloading particular teeth during mastication in the affected area and to parafunction. The presence of teeth within the alveolar bone seems to be a requirement for the apposition of bone.

It has also has been observed that a correlation between enlarging tori and the use of estrogen and progesterone among women may exist. Furthermore, there is a strong possibility that thumb sucking which is commonly noted during ultra-sonography of the fetus may be related to the presence of tori in newborn children.

Occasionally, it has been clinically noted that a lower distal extension partial denture if left out over a period of time will to impinge upon the soft tissues in the lingual cuspid/bicuspid region. It is the authors' opinion that due to flexural induced stresses in the mandible of this region, bone apposition does occur, thus making it difficult or impossible to seat the partial denture. Heretofore, it has been assumed that the partial denture was merely settling into the tissue and causing impingement whereas bone enlargement in these areas appears to be the real culprit.

A literature search does not provide any studies relating specifically to the enlargement of tori or other exostoses among the edentulous. Author (JOG) has been informed by other clinicians and lab technicians with whom he has consulted that the most common site for complete upper dentures to fracture is in the region of the palatal median suture line. This region of failure in full dentures is also the area of greatest stress concentration within the prostheses, especially during clenching. Bilateral compressive forces created during occlusal loading can result in increased stress in the midline of the upper denture base, thus can produce fracture at this site. Replacement with a metal palate to the prosthesis is necessitated in these cases as fracture can recur when using all acrylic palates. Similarly, the presence of maxillary teeth, acting as do teeth in the full upper denture base material create stress in the mid palatal region. It appears that this could contribute to the formation of tori, whereas the absence of natural teeth would conversely stop or prevent the enlargement of tori. It now becomes evident that in edentulous patients there are no teeth to impart stresses to the bone, thus the bone does not enlarge.

Conclusions

A study of three typical dentate patients has disclosed the increasing size of both mandibular and maxillary tori in specific areas over a period of time. Parafunctional habits, as in bruxing and clenching causing increased stress within the bone, in addition to genetics appear to be factors in the etiology of tori and are related to the increasing size of these tori in specific locations. Findings have indicated that the use of hormone replacement therapy, such as estrogen and progesterone, and the use of birth control medications may be related to the increased size of tori. It is commonly noted that tori are present in the areas of stress concentration of bone; such as the maxillary median suture line, as well as the lingual surface of the mandible in the region of the cuspid and bicuspids. Bone deposition in areas of stress concentration may be enhanced as a result of a piezoelectric effect in bone. Removal and recurrence of these subsequent boney outgrowths is noteworthy.

This hypothesis is based on accepted bioengineering mechanisms of stress and biocorrosion are presented as such. An acceptance of the mechanism of stress concentration involved during the dynamics of excessive masticatory loading and parafunctional activity with their effects on bone may provide a better understanding, as well as treatment of some of the dilemmas encountered following prosthetic replacements. Further longitudinal studies to verify and quantify stress concentration over time in these regions of the mandible and maxilla under an excessive load presents a challenge to the researcher. Studies to determine why tori as well as exostoses occur on one arch and not the opposing arch are also encouraged by the authors. Longitudinal clinical studies to gather more information on edentulous patients are encouraged by the authors to verify all of the aforementioned hypotheses. Furthermore, a study of the tori size after the removal of teeth would be a major contribution to the dental literature. The authors suspect that the tori do not enlarge and may become smaller due to the lack of stimulation from the loss of their teeth and that most of stress occurs within the dentures.

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