ECRONICON OPEN ACCESS

EC DENTAL SCIENCE
Review Article

The Increased Prevalence of Malocclusion in Modern Humans: An Integrative Review

Silvana Silveira[1]*, Wilma Alexandre Simões[3], Francisco José Moraes Macedo[4] and Patricia Valério[2]

[1]*Specialist in Functional Jaw Orthopedics, Member of the Scientific Committee of the Brazilian Academy of Functional Maxillofacial Orthopedics, Brazil*

[2]*Post Doctor Researcher at Biological Science Institute, Federal University of Minas Gerais, Brazil and Professor of Specialization Course of Functional Jaw Orthopedics, Cruzeiro do Sul University, Brazil and Scientific Coordinator at Wilma Simões European Institute, Portugal*

[3]*Researcher at CEPECRAF - Craniofacial Growth Research Center, UNICSUL, São Paulo and Professor of Specialization Course of Functional Jaw Orthopedics, Cruzeiro do Sul University and Professor at FAOA Faculty, Brazil and Scientific Coordinator at Wilma Simões European Institute, Portugal*

[4]*Researcher at CEPECRAF - Craniofacial Growth Research Center, UNICSUL, São Paulo and Professor of Specialization Course of Functional Jaw Orthopedics, Cruzeiro do Sul University, Brazil*

***Corresponding Author:** Silvana Silveira, Specialist in Functional Jaw Orthopedics, Member of the Scientific Committee of the Brazilian Academy of Functional Maxillofacial Orthopedics, Brazil.

Received: September 05, 2018; **Published:** November 12, 2018

Abstract

The increased prevalence of malocclusion in modern humans is a reality described in 92% of the evaluated anthropological studies. During the industrial revolution, there was a major dietary shift, with hard, dry and fibrous foods being replaced by a processed and softer diet causing a sudden reduction of the functional demands on the stomatognathic system. This study evaluates, the level of scientific evidence and the grades of recommendation for the selected articles. We can infer that both anthropologists and dentists have shown a relatively increased interest in this subject in the last three decades. The above-mentioned criteria suggest the high scientific accuracy of the studies. They also point out that there is reasonable evidence to support the malocclusion/function relationship, and that there are benefits in understanding this interrelationship. Therapies aimed to restore the functional balance, as proposed by Functional Jaw Orthopedics, should be the goal of the treatment so that the function itself restores and maintains the system.

Keywords: *Chewing; Craniofacial Growth; Tooth Wear; Occlusion; Anthropology; Dental Attrition; Functional Jaw Orthopedics*

Introduction

By introducing an anthropological perspective into dentistry, we provide a broader view of the nature and extent of the prevalence of malocclusion in modern populations. A combination of anthropological evidence with clinical knowledge and experience allows a historical and scientific approach to the evolution of occlusion in humans and a think over the concepts and dogmas created throughout history [1-3].

The prevalence of caries, periodontal disease, and malocclusion in modern post-industrial societies is significantly higher than in pre-industrial societies [4]. In populations with an attritive diet, consisting of hard, dry and fibrous foods, the physiological and natural wear of the teeth maintains the functional masticatory balance. However, an abrupt change in eating habits occurred in the transition to contemporary lifestyle, leading to a major modification of occlusion in modern humans [3,5-20].

Therefore, we believe that it is very useful to carry out a bibliographic review organized under specific criteria - an integrative review - to understand the importance of function in the etiology of malocclusions.

Methods

In October and November 2016, a search for indexed publications on the Medline/Pubmed, PMC (Pubmed Central) and Google Academic databases was carried out, as these databases allow searching by established criteria. The following descriptors were taken into account: chewing, craniofacial growth, tooth wear, occlusion, anthropology, dental attrition, Functional Jaw Orthopedics.

The following exclusion criteria were established for the selection of the articles: papers related to diseases (since pathologies are not the focus of our investigation); articles dealing with nutrition/diet without correlation with craniofacial development and/or occlusion; descriptions of clinical cases (for having little scientific relevance); studies on animals (since the animals are considered biological reagents, the results of the experiments can be affected by the conditions of the species used, in relation to environmental, genetic and experimental variables). All abstracts selected in the initial search were read and the exclusion criteria were applied.

Flowchart

Even considering the review of contemporary scientific publications to be one of the basic principles of evidence-based practice, we have defined the scope of our research to the last six decades (from 1/1/1958 to 31/11/2016), given that 75.5% of the selected articles focus on anthropological aspects as shown in figure 1.

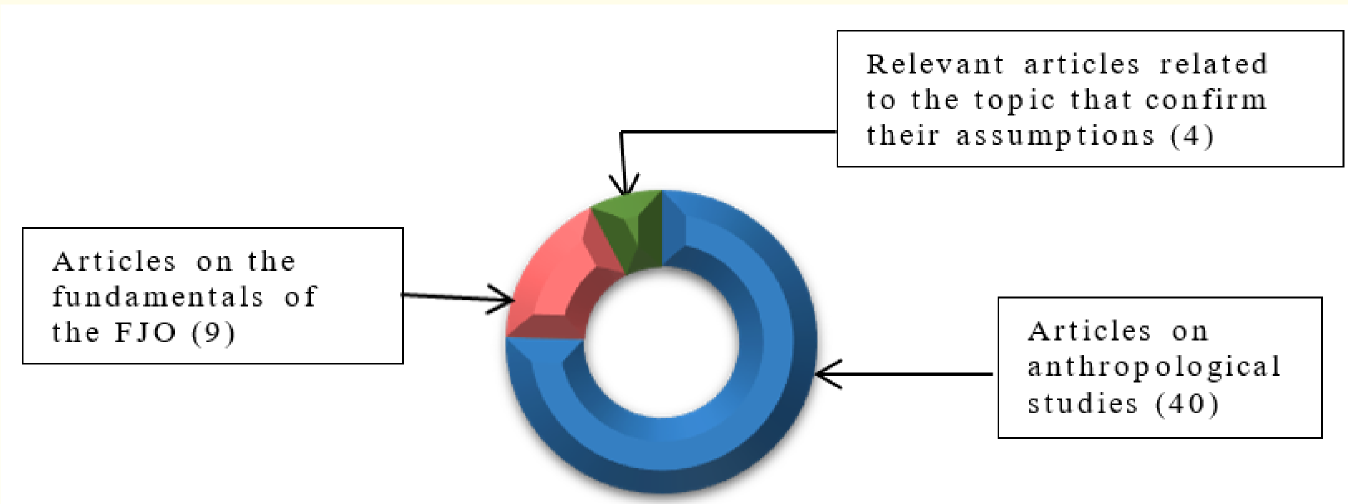


Figure 1: *Publications by the area.*

As far as the years of publication are concerned, there has been a relative change over the last six decades and a significant increase in the number of published works in the 1990s and in the current decade, stressing the obvious interest of both anthropologists and dentists in the topic as shown in graph 1 and graph 2

The statistical relevance of these graphs was evaluated by Prism.

No articles were selected for the years 2010 and 2015.

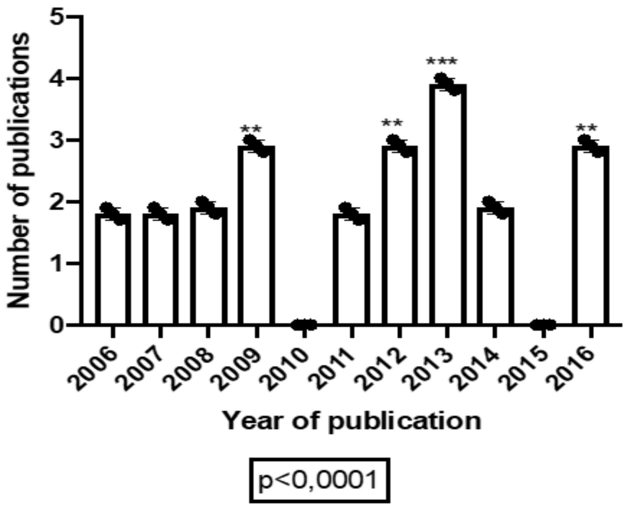
The bibliographic references of the selected articles were analyzed, and those found to be relevant to the subject were included. Articles by renowned authors in the area were also taken into account.

Full-text articles were retrieved through the Capes journals portal and the PMC database (Pubmed Central), where some articles were available. Publications in foreign languages were translated by English-speaking translators.

Discussion

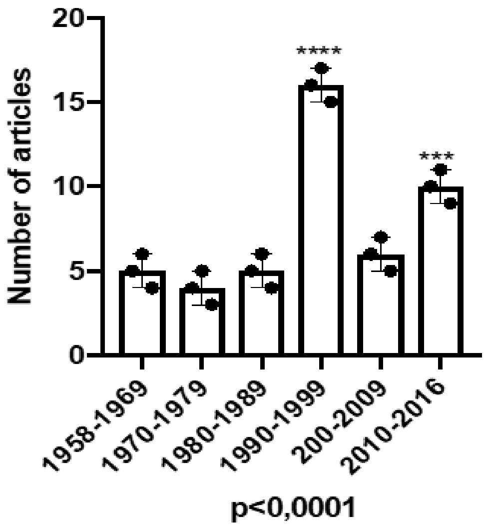
The articles included in this review were classified according to their level of scientific evidence and recommendation, according to the "Oxford Centre for Evidence-based Medicine" table.

Among the selected articles 33 show a of 2C and a B, indicating a high scientific rigor and showing that there is reasonable evidence to support the malocclusion/function relationship. In other words, that there is a benefit in understanding this interrelationship.



Treatment (between columns)	42.53	10	4.253	F (10, 22) = 519.8	P<0.0001
Residual (within columns)	0.1800	22	0.008182		
Total	42.71	32			
Data summary					
Number of treatments (columns)	11				

Graph 1: *Distribution of the number of publications in the last decade.*



Treatment (between columns)	316.0	5	63.20	F (5, 12) = 63.20	P<0.0001
Residual (within columns)	12.00	12	1.000		
Total	328.0	17			
Data summary					
Number of treatments (columns)	6				

Graph 2:*Distribution of the number of publications in the last six decades.*

Journal	Recommendation	Evidence level
J Med Dent Sci. 2002 Mar:49(1):19-26.	B	2B
Australia n Dental J 1958 Feb;3(1):39-52.	B	2B
Aust Dent J. 1965 Feb;10(1):63-8.	B	2B
Acta Odontol Scand. 1964 Dec;22:597-678.	B	2B
J Oral Rehabll. 1997 Jul;24(7):522-526.	D	5
Am J Hum Genet. 1961 Mar; 13(1 Pt 1): 1-8.	B	2B
Actual Odontostomatol (Paris). 1990 Dec;(172):561-8. French.	D	5
Sci Rep. 2016 Sep 13;6:33316. w.	B	2B
Annual Review of Anthropology. 1995 Oct(24): 185-213.	B	2B
Angle Orthod. 1989 Spring;59(1):61-4.	B	2B
Am J Orthod. 1984 Nov;86(5):419-26.	D	5
Am J Orthod Dentofacial Orthop. 1990 Apr;97(4):349-57. Review.	B	2B
Am J Phys Anthropol. 1990 Jul;82(3):257-65.	B	2B
Hum Biol. 1986 Feb;58(1):61-6.	B	2B
Arch Oral Biol. 1985;30(1):65-9.	B	2B
Am J Orthod. 1981Mar;79(3):250-62.	B	2B
J Dent. 1992 Dec;20(6):333-41. Review.	D	5
Am J Phys Anthropol. 2013Aug;151(41)544-57.	B	2B
Am J Orthod Dentofacial Orthop. 2007 Jun;131(6):710-6.	B	2B
Coll Antropol. 2014 Sep;38(3):993-1000.	D	5
Scand J Dent Res. 1979 Apr;87(2):79-90.	B	2B
Scand J Dent Res. 1979 Apr;87(2):91-7.	B	2B
Am J Phys Anthropol. 2013 Jul;151(3):477-91.	B	2B
Int J Dent. 2012; 2012: 741405. Published online 2012 Dec 10.	D	5
Arch Oral Biol. 1983;28(5):401-8.	B	2B
Orthod Fr. 2006 Mar;77(1):113-3S. French.	D	5
Am J Phys Anthropol. 1994 Jul;94(3):327-37.	B	2B
Eur J Orthod. 2004 Apr;26(2):151-6.	B	2B
Am J Phys Anthropol. 1990 Jul;82(3):385-95.	B	2B
Afr Dent J. 1993;7:6-10.	B	2B
Arch Oral Blol. 1964 May-June;9:269-80.	B	2B
J Prosthet Dent 1977 Oct;38(4):459-69.	D	5
PLOS One. 2011;6(12):e28387.	B	2B
Funct Orthod. 2001 Spring;18(1):22-30.	D	5
Orthod Fr. 1971;42:3330-47. French. No abstract available.	D	5
Orthod Fr. 1992;63 Pt 2:435-41. French.	D	5
Orthod Fr. 1968;39:509-24. French. No abstract available.	D	5

Prim Dent Care. 2008 Apr;15(2):65-9. Review.	D	5
PLOS one. 2013;81(1): e80771. Published online 2013 Nov 20.	B	2B
Angle Orthod. 1983 Apr;53(2):157-64.	B	2B
Homo. 2009;60(4):295-306. Epub 2009 May 9.	D	5
Compend Contin Educ Dent. 2009 Jun;30(5):292-300.	B	2B
Am J Phys Anthropol.1997 Aug; 103(4): 497-505.	B	2B
Am J Orthod Dentofacial Orthop. 1990 Sep;98(3):222-30.	B	2B
J Clin Pediatr Dent. 1996 Fall;21(1):1-7. Review.	D	5
Ortodontia. Sociedade Pauista de Ortodontia. 1979 Jan-Apr;12(1):19-28.	D	5
PLOS One.2013;8(4)1:e62263. Published online 2013 Apr 24.	D	5
Ann Anat. 2016 Jan;203:59-68.	D	5
Odontology. 2012 Jan;100(1):1-9. Review.	D	5
Eur J Orthod 1992 Feb; 14(1): 31.	D	5
Proc Finn Dent Soc. 1991;87(2):239-44. Review.	B	2B
Scand J Dent Res. 1990 Jun; 98(3):242-7.	B	2B
J Dent Res. 1998 Nov;77(11):1860-3. Review.	B	2B

Table 1: *Recommendation degree and scientific evidence level.*

As far as the increased prevalence of malocclusion in modern humans is concerned, 92% of the anthropological evaluation articles selected and used in this article dealing with the subject support the view that the stomatognathic system has not had enough time to adapt to dietary changes, still maintaining an anatomical and functional configuration to carry out an abrasive function, which should start in childhood and persist throughout adulthood [11,19,21,22]. In an attempt to create an ideal occlusion, much emphasis has been placed on the cusp-fossa relationships for natural and artificial teeth; however, during millions of years, the stomatognathic system has undergone evolutionary adaptations in which occlusion was under heavy masticatory stress, providing pronounced occlusal and interproximal friction [23]. The elimination of dental cusps (by friction) also eliminates occlusal interferences, providing the formation of horizontal occlusal planes and allowing a physiological functional occlusion in which the centric occlusion fully coincides with the position of maximum intercuspation [24-30].

Contrary to what we see nowadays, the masticatory angles or M.F.A., Planas Masticatory Functional Angles, were perfectly balanced, starting from the centric occlusion and were built with wide, bilateral, alternating mandibular excursions [31-33].

In his work, Canalda [7] quotes Claude Bernard's famous words: "The function makes the organ" and the organ provides the function, and affirms that the function only attains its objective if it is physiologically normal and the grinding of the food takes place by alternative laterality.

Chewing, the first of the functions attributed and performed by the masticatory apparatus, is a true "functional matrix" capable of stimulating the growth of dental arches and maxillaries. Therefore, specific interceptive and preventive treatments should be applied as early as possible, still in the phase of deciduous dentition [33].

Beyron [5] reports that all the 46 adult skulls studied showed lateral occlusion contact in several teeth. The premolars and the working-side antagonist molars showed a sliding contact of the lateral position to the intercuspal (group function), and that occlusal contact during mastication occurred mainly in the position of maximum intercuspation.

Rose and Roblee [34] do not link the increased prevalence of crowding and malocclusion to attrition reduction, but to the shift to a softer diet, causing low functional demand and consequently bone atrophy determinant for tooth to denture base discrepancy (the difference between the dental arch length and the sum of the crown diameters of the teeth in the jaw).

However, most of the articles analyzed support the hypothesis that craniofacial skeletal growth is regulated by masticatory stress and that both dimensional changes of the jaws and the absence of dental wear may have contributed to the greater occlusal variation in modern humans [1-25,27-49].

According to the principles of Neuro-Occlusal Rehabilitation, occlusion is the result of neuromuscular control over the masticatory system, and neuromuscular activity is under the influence of dental contacts. In order to obtain the best masticatory efficiency, the occlusal plane should be modulated throughout life, thus allowing freedom of sliding mandibular movements with the highest number of physiological dental contacts [48]. These works provide support for the development of therapies that promote the enlargement of the maxillary dimensions, rather than the removal of teeth, which contributes to the further atrophy of an already deficient dental arch, as well as therapies that restore the function and the craniofacial growth in a balanced way, promoting a harmonic relationship between the dentoalveolar complex and the skeletal base [14,21,31-33,37-39,50].

Townsend GC., *et al.* [45], Varrela [46,47], and Fiorin E., *et al.* [18] consider genetic and environmental factors to have the greatest influence on variations in tooth position. On the other hand, Li [51] and Mockers O., *et al*. [26] suggest that crowding has a genetic cause and may not be related to changes in environmental factors (masticatory activity). However, one should note that, in the Mockers study, the prevalence of crowding is around 13%, much lower than in modern populations.

Normando D., *et al.* [50] reported a high frequency of malocclusion in the studied population. This fact was mainly associated to the high frequency of mesial molar and anterior crossbite relation, but Reinhardt [39] considers this type of occlusion as characteristic of individuals with a pronounced attritive diet and significant occlusal and interproximal tooth wear.

Sarig R., *et al.* [52] concluded that jaw-teeth size discrepancy is not a recent phenomenon; however, their study examined only one single ancient skull

Sakashita R., *et al.* [53] did not find any significant differences in the frequencies of the discrepancy between groups of different social classes from the Yin-Shang period in China, as they did not show fundamental differences in diet and the differential load on the masticatory system was small.

Crothers [16] concluded that under physiological conditions the dentofacial complex is not a static entity and that compensation for the effects of wear and a maintenance of facial height take place through compensatory eruptive, alveolar and skeletal mechanisms. On the other hand, Levers and Darling [23] suggests that if the tooth wear is not functional, a loss of the vertical dimension may occur due to a “collapse” of these compensatory mechanisms. Simões [42,43] suggests that tooth wear has an effect on the temporomandibular joints (TMJ) that undergo changes that seem to be a response to the occlusal alteration due to stress.

Helm and Prydsö [19] studied the skeletal remains of 278 mediaeval Danes and reported that the emergence of the third molar was estimated as occurring at the age of 14, attributing this precocity to pronounced friction not only on occlusal surfaces, but also interproximal.

Presswood and Toy [38] and Benazzi., *et al.* [35] claim that tooth wear changes the distribution of stress, regardless of the primary morphology of the teeth. They also report that non-carious cervical lesions are a modern pathology and suggest that the lack of tooth wear, a characteristic of modern societies, may be the main causative factor for these lesions.

Conclusion

After a careful review of the selected scientific literature, we can say that there is sufficient evidence to claim that the stomatognathic system has undergone a morphofunctional modification over the last 150 - 300 years, a direct result of the sudden shift in eating habits during this period, which contributed to the increased prevalence of malocclusion in modern humans.

In spite of evolution, the stomatognathic system continues anatomically and functionally designed to perform a functional abrasive function.

We can, therefore, infer that the basic causes for the increased prevalence of malocclusion in modern humans are due to the dietary shift, with hard, dry and fibrous foods being replaced by a processed and softer diet that doesn`t stimulate the right functional demand for the proper craniofacial growth. A significant decrease in the interproximal and occlusal attrition was observed, also due to the dietary shift mentioned above, causing several large-scale occlusal imbalances, such as non-cervical carious lesions and crowding, as well as the adjustment of maxillomandibular growth.

It is important to note that the skulls examined in these anthropological studies show a helicoidal occlusal plane, resulting from a vigorous and physiological wear different from the occlusal wear caused by bruxism-like parafunction.

Therapies should aim to restore the functional balance of the masticatory apparatus and to correct the masticatory cycles (as proposed by the Functional Jaw Orthopedics) so that the function itself restores and maintains the system composed by the binomial function/form.

Bibliography

1. Amarsaikhan B., *et al*. "Influence of environmental factors on tooth displacement". *Journal of Medical and Dental Sciences* 49.1 (2002): 19-26.
2. Barrett MJ. "Dental observations on Australian Aborigines continuously changing functional occlusion". *Australian Dental Journal* 3.1 (1958): 39-52.
3. Evensen JP and Øgaard B. "Are malocclusions more prevalent and severe now? A comparative study of medieval skulls from Norway". *American Journal of Orthodontics and Dentofacial Orthopedics* 131.6 (2007): 710-716.
4. Barrett MJ., *et al*. "A long-term study of the dental and craniofacial characteristics of a tribe of Central Australian Aborigines". *Australian Dental Journal* 10.1 (1965): 63-68.
5. Beyron H. "Occlusal relations and mastication in Australian Aborigines". *Acta Odontologica Scandinavica* 22 (1964): 597-678.
6. Buschang PH., *et al*. "The effects of bolus size and chewing rate on masticatory performance with artificial test foods". *Journal of Oral Rehabilitation* 24.7 (1997): 522-526.

7. Canalda K. ["Homage to Pedro Planas"]. *Actual Odontostomatol (Paris)* 172 (1990): 561-568.

8. Cheronet O., *et al*. "Morphological change in cranial shape following the transition to agriculture across Western Eurasia". *Scientific Reports* 6 (2016): 33316.

9. Corruccini RS. "An epidemiologic transition in dental occlusion in world populations". *American Journal of Orthodontics and Dentofacial Orthopedics* 86.5 (1984): 419-426.

10. Corruccini RS. "Orthodontistry and dental occlusion in Etruscans". *Angle Orthodontist* 59.1 (1989): 61-64.

11. Corruccini RS. "Australian Aboriginal tooth succession, interproximal attrition, and Begg's theory". *American Journal of Orthodontics and Dentofacial Orthopedics* 97.4 (1990): 349-357.

12. Corruccini RS and Choudhury AFH. "Dental occlusal variation among rural and urban Bengali youths". *Human Biology* 58.1 (1986): 61-66.

13. Corruccini RS and Whitley LD. "Occlusal variation in a rural Kentucky community". *American Journal of Orthodontics and Dentofacial Orthopedics* 79.3 (1981): 250-262.

14. Corruccini RS., *et al*. "Bite-force variation related to occlusal variation in rural and urban Punjabis (North India)". *Archives of Oral Biology* 30.1 (1985): 65-69.

15. Corruccini RS., *et al*. "Occlusal variation in Australian Aboriginals". *American Journal of Physical Anthropology* 82.3 (1990): 257-265.

16. Crothers AJ. "Tooth wear and facial morphology". *Journal of Dentistry* 20.6 (1992): 333-341.

17. Eng CM., *et al*. "Bite force and occlusal stress production in hominin evolution". *American Journal of Physical Anthropology* 151.4 (2013): 544-557.

18. Fiorin E., *et al*. "Study of dental occlusion in ancient human remains: a methodological approach". *Collegium Antropologicum* 38.3 (2014): 993-1000.

19. Helm S and Prydsö U. "Prevalence of malocclusion in medieval and modern Danes contrasted". *Scandinavian Journal of Dental Research* 87.2 (1979): 91-97.

20. Larsen CS. "Biological changes in human populations with agriculture". *Annual Review of Anthropology* 24 (1995): 185-213.

21. Helm S and Prydsö U. "Assessment of age-at-death from mandibular molar attrition in medieval Danes". *Scandinavian Journal of Dental Research* 87.2 (1979): 79-90.

22. Hlusko LJ., *et al*. "Neanderthal teeth from Moula-Guercy, Ardèche, France". *American Journal of Physical Anthropology* 151.3 (2013): 477-491.

23. Levers BG and Darling AI. "Continuous eruption of some adult human teeth of ancient populations". *Archives of Oral Biology* 28.5 (1983): 401-408.

24. Limme M. ["Interception in the primary dentition: mastication and neuro-occlusal rehabilitation"]. *Revue d'Orthopédie Dento Faciale* 77.1 (2006): 113-135.

25. Macho GA and Berner ME. "Enamel thickness and the helicoidal occlusal plane". *American Journal of Physical Anthropology* 94.3 (1994): 327-337.

26. Mockers O., *et al*. "Dental crowding in a prehistoric population". *European Journal of Orthodontics* 26.2 (2004): 151-156.

27. Molnar S and Molnar IM. "Dental arch shape and tooth wear variability". *American Journal of Physical Anthropology* 82.3 (1990): 385-395.

28. Mugonzibwa EA. "Occlusal survey in a group of Tanzanian adults". *African Dental Journal* 7 (1993): 6-10.

29. Murphy TR. "The relationship between attritional facets and the occlusal plane in aboriginal Australians". *Archives of Oral Biology* 9 (1964): 269-280.

30. Neiburger EJ. "Flat-plane occlusion in the development of man". *Journal of Prosthetic Dentistry* 38.4 (1977): 459-469.

31. Planas P. ["The Planas law of the minimal vertical dimension"]. *Revue d'Orthopédie Dento Faciale* 39 (1968): 509-524.

32. Planas P. ["Neuro-occlusal rehabilitation: NOR"]. *Revue d'Orthopédie Dento Faciale* 42 (1971): 333-347.

33. Planas P. ["Equilibrium and neuro-occlusal rehabilitation"]. *Revue d'Orthopédie Dento Faciale* 63.2 (1992): 435-441.

34. Rose JC and Roblee RD. "Origins of dental crowding and malocclusions: an anthropological perspective". *Compendium of Continuing Education in Dentistry* 30.5 (2009): 292-300.

35. Benazzi S., *et al*. "The evolutionary paradox of tooth wear: simply destruction or inevitable adaptation?" *PLoS ONE* 8.4 (2013): e62263.

36. Kaidonis JA., *et al*. "An anthropological perspective: another dimension to modern dental wear concepts". *International Journal of Dentistry* (2012): 741405.

37. Page DC. "How to promote and provide functional jaw orthopedics". *Functional Orthodontist Journal* 18.1 (2001): 22-30.

38. Presswood RG and Toy A. "Is there such a thing as a "healthy occlusion"?: lessons from history". *Primary Dental Care* 15.2 (2008): 65-69.

39. Reinhardt GA. "Attrition and the edge-to-edge bite: an anthropological study". *Angle Orthodontist* 53.2 (1983): 157-164.

40. Rogers JR., *et al*. "Murray James Barrett, dental anthropologist: Yuendumu and beyond". *HOMO - Journal of Comparative Human Biology* 60.4 (2009): 295-306.

41. Sessle BJ., *et al*. "Effect of functional appliances on jaw muscle activity". *American Journal of Orthodontics and Dentofacial Orthopedics* 98.3 (1990): 222-230.

42. Simões WA. "Mastigação". *Ortodontia* 12.1 (1979): 19-28.

43. Simões WA. "Insights into maxillary and mandibular growth for a better practice". *Journal of Clinical Pediatric Dentistry* 21.1 (1996): 1-7.

44. Toro-Ibacache V., *et al*. "The relationship between skull morphology, masticatory muscle force and cranial skeletal deformation during biting". *Annals of Anatomy* 203 (2016): 59-68.

45. Townsend GC., *et al*. "Genetic, environmental and epigenetic influences on variation in human tooth number, size and shape". *Odontology* 100.1 (2012): 1-9.

46. Varrela J. "Occurrence of malocclusion in attritive environment: a study of a skull sample from Southwest Finland". *Scandinavian Journal of Dental Research* 98.3 (1990): 242-247.

47. Varrela J. "Genetic and epigenetic regulation of craniofacial development". *Proceedings of the Finnish Dental Society* 87.2 (1991): 239-244.

48. Varrela J. "Dimensional variation of craniofacial structures in relation to changing masticatory-functional demands". *European Journal of Orthodontics* 14.1 (1992): 31.

49. Young WG. "Anthropology, tooth wear, and occlusion aborigine". *Journal of Dental Research* 77.11 (1998): 1860-1863.

50. Normando D., *et al*. "Dental occlusion in a split Amazon indigenous population: genetics prevails over environment". *PLoS ONE* 6.12 (2011): e28387.

51. Li CC. "The diminishing jaw of civilized people". *American Journal of Human Genetics* 13.1 (1961): 1-8.

52. Sarig R., *et al*. "Malocclusion in early anatomically modern human: a reflection on the etiology of modern dental misalignment". *PLoS ONE* 8.11 (2013): e80771.

53. Sakashita R., *et al*. "Diet and discrepancy between tooth and jaw size in the Yin-Shang period of China". *American Journal of Physical Anthropology* 103.4 (1997): 497-505.

Volume 17 Issue 12 December 2018