Shortened Dental Arch: A Review of Current Treatment Concepts

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It is generally assumed that dentition has ceased to be a predominant selection factor in the process of human evolution. With differentiation and reintegration of the human species, gross differences in the morphology and physiology of the stomatognathic system have become apparent. Variability and adaptation of this system have proven that deviations from what may be considered ideal are not pathologic but may, in fact, prove to be a range of normality in this general pattern of evolution. The treatment of patients according to inflexible postulates may be detrimental to the individual patient and the concept of a variable and patient-specific optimal dentition should be considered, especially in the context of the shortened dental arch.

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WITH SIGNIFICANT advances in materials science and the refinement of clinical techniques, the major challenge for prosthodontics today becomes not the creation of dental restorations, but the successful physiologic integration of these artificial replacements into a dynamic oral system.

Demographic data indicate that the relative incidence of the edentulous state is falling.[1] It is believed that the percentage of edentulous persons in the 75+ age group will decrease by about 50% over the 35-year period from 1990 to 2025.[2] Nevertheless, the absolute number of edentulous and partially edentulous patients is on the rise due to a significant numerical increase in this segment of the population.[3] As we move into a new millennium, a new class of partially edentulous patients presents a unique challenge to the treating dentist. In the past half century, advances in endodontics, periodontics, and prosthodontics have allowed us to treat and utilize teeth formerly considered non-restorable and allowed us to replace edentulous spans with fixed prostheses. The partially edentulous patient is less likely to consider removable partial dentures as an ideal option for rehabilitation of their dentition. However, financial concerns and dependence on limited dental insurance coverage may render these patients untreatable with current fixed and implant-treatment modalities.

A significant number of these patients will present with shortened dental arches (SDA) in either the maxilla or the mandible. A shortened dental arch is defined as a dentition where most of the posterior teeth are missing.[4] Sound treatment philosophies must be developed to provide appropriate treatment for this subgroup of prosthodontic patients.

Evolution of the Masticatory System

An overview of the evolution of the mammalian stomatognathic system and its relation to current concepts in occlusion provide insights into the requirements for harmonious stomatognathic function in human beings.

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The evolution of the vertebrates from filter feeding jawless fish to extant species has taken almost five hundred million years.[5] Evolutionary changes in the head, jaws, and teeth have been critical in ensuring mammals' advantage.

It has been suggested that it is the evolution of the mammalian jaws and jaw joints, along with changes in ear structure, that is a key to mammalian success.[6] With prolonged intrauterine growth and subsequent suckling, the period of growth when a young animal has to fend for itself is greatly reduced. Hence the need for continual changes and enlargement of a functioning dentition is lessened, and fewer generations of teeth are required. Thus, instead of being polyphyodont, mammals are mostly diphyodont.

Fossil evidence shows that there was a gradual increase in size of the tooth-bearing surface of the lower jaw, and reduction of the posterior segment. The mandible gradually extended posteriorly until it came into contact with the squamosal portion of the temporal bone where a new jaw joint, the temporomandibular joint, was established.

The tooth form gradually evolved to consist of a series of cusps, initially in the mesial and distal aspects of the crown, but later forming a triangle of cusps called the trigon. The cusps were subsequently added posteriorly to the lower molars to form a heel or a talonid. Thus, primitive cuspal morphology was established.[7]

The discovery of several specimens of a small fossil hominid in the Hadar region of Ethiopia in the 1970s dramatically changed our concepts of the timing and the order of changes of human evolution.[8,9] It is believed that two branches arose from the early hominids. One of these branches led to the first members of the genus Homo, Homo habilis. The transition from the early hominid, Australopithecus Afarensis, to Homo Habilis has not been well documented by fossil records but appears to have resulted in a gradual evening out of the whole dentition with diminution of its relative size,[10] loss of diastemas mesial to the canines, a more parabolic dental arch, lessening of subnasal prognathism,[11] and a decrease in the size and prominence of the zygomatic arch.

The Homo line is distinguished by encephalization seen initially in Homo habilis, but much increased in subsequent species. Thus the relative proportion of cranium to jaws has changed in humans due to both an increase in cranium size and a decrease in jaw size (Fig 1).

The development of cooking methods allowed greater ease of mastication. Having good dentition was no longer necessary for survival and the freeing of human dentition from evolutionary pressure was accentuated, a process that may have started with the acquiring of upright posture and bipedalism.[12]

Dental reduction has been so widespread among human populations to render the phenomenon of reduced tooth size worthy of scientific explanation. One model invoked to explain structural reduction in organisms is referred to as the probable mutation effect.[13]

According to this model, structures no longer functional due to environmental or cultural changes will experience a relaxation of selection pressure, permitting an accumulation of mutations in the population that will inevitably result in a reduction in size or eventual loss of the affected structure.[14]

Opponents of the probable mutation effect theory propose models of dental reduction based on natural selection which, unlike the earlier theory, is testable in both modern and archeological populations.[15-17]

Therefore, the net effect has been a reduction in direct dependence on the stomatoganthic system for survival and a resultant alteration in the size and function of dentition. Current concepts of occlusion emphasize the capability of the masticatory system to adapt to or compensate for some deviations within the range of tolerance of the system.[18] Normal occlusion implies a situation commonly found in the absence of disease, and normal values in a biological system are given within a variable physiological range. Therefore, normal occlusion should imply more than a range of anatomically accepted values, and should also indicate physiological adaptability and the absence of pathological manifestations.

The concept of an ideal or optimal occlusion refers both to an esthetic and to a physiological ideal. The emphasis has moved more and more from esthetic and anatomical standards to a current concern with function, health, and comfort that may include patients exhibiting SDA.

Although a concept of ideal occlusion enables a student to understand stomatognathic physiology and occlusal concepts, most patients with functionally sound occlusions and a healthy periodontium will not require invasive treatment to restore their dentition to an ideal.

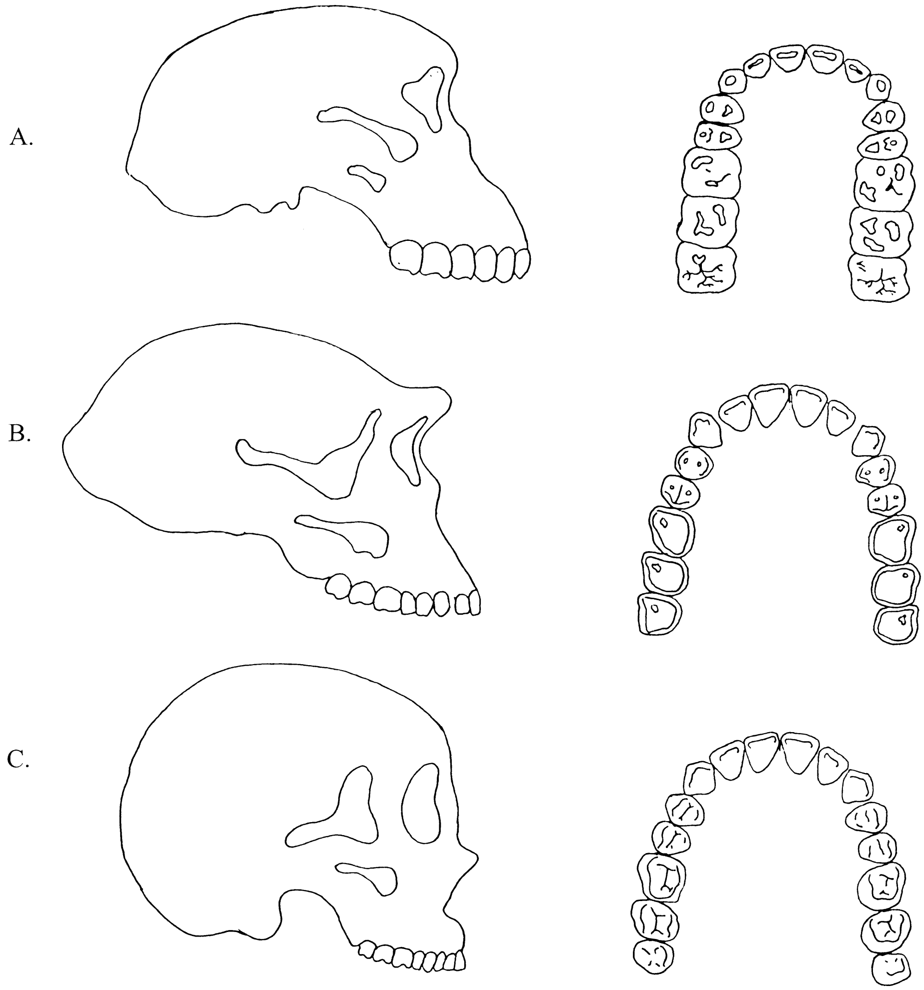

Figure 1. Representation of dental arch diminution with corresponding increases in cranial capacity.

Basis of a Shortened Dental Arch Concept

Prosthodontists often approach the treatment of the shortened dental arch as a reconstructive or rehabilitative problem. These terms are introduced to differentiate between (1) rehabilitation procedures aimed at restoring dental and temporomandibular joint function and (2) reconstruction that implies a more anatomically oriented restoration of tooth surfaces.[18]

The decision to restore all the teeth in the mouth should be made only after all intended advantages of such treatment are carefully considered and are found to outweigh the benefits of a more limited yet therapeutically sound alternative. The decision should be based on the aim to create and maintain a healthy occlusion. A healthy occlusion as described by Ash and Ramfjord[19] implies an absence of pathology not only on the dentition but also in the periodontal, osseous, and muscular components of the oral system. An orthopedically stable centric position, axial loading of the dentition, and guidance from centric to eccentric positions are also essential. The last requirement is adaptability of the system to changes in other components in the system.

The shortened dental arch concept includes an examination of the dentition within the functional needs of the stomatognathic systems and the requirements of the dentition to maintain a pathology-free system.

Figure 2. Anatomically complete dental arch.

Figure 4. Extremely shortened dental arch with asymmetry.

The Shortened Dental Arch

A classification for the shortened dental arch, suggested by Kayser,[20] groups patients according to the number of teeth remaining in the arch and the symmetry of the shortening (Figs 2–4).

A system considering occlusal units as premolar equivalents was also developed in which a molar is equivalent to two premolar units and a premolar is equivalent to a single occlusal unit. Thus a single arch of four molars and four premolars would account for 12 occlusal units.

Varying opinions regarding the influence of a shortened dental arch on the masticatory system have been reported.[21-23] A major objection to the replacement of bilaterally distal edentulous spaces was poor patient acceptance of a traditional removable partial denture;[24] however, the success of implant-borne prostheses has provided a viable alternative treatment modality for the shortened dental arch situation.

Figure 3. Symmetrically shortened dental arch.

The occlusal preservation target was developed to differentiate the dental arch into strategically important regions.[25] The anterior and premolar regions are functionally and esthetically indispensable throughout life and are considered a priority in rehabilitation. The molar regions play important roles in mastication and stabilization and are usually restored once satisfactory rehabilitation of the anterior segments is completed. In essence, the shortened arch concept allows for treatment and maintenance of strategically important segments before segments of secondary importance are restored.

Shortened Dental Arches and Oral Function

The functional capabilities of SDA were assessed by chewing tests based on the release of light-absorbing materials when chewing raw carrots.[26]

The chewing tests showed a highly significant correlation between masticatory capacity and the number of occlusal units. With a decreasing number of occlusal units, the numbers of chewing strokes needed before swallowing increased.

The subjects started complaining about their masticatory function when the number of occlusal units was less than four in symmetrically shortened arches and less than six in asymmetrically shortened arches.

The preliminary conclusion was that there is sufficient adaptive capacity in SDA when at least four occlusal units are left, preferably in a symmetrical position, and this assumption has not been disproved.

Subjective Experience of Mastication in Patients with an SDA

A study was carried out to evaluate the subjective experience of patients masticating with a shortened dental arch.[27]

The aim was to determine whether subjects with an SDA displayed an increased incidence of chewing problems and whether they had a different food perception and food selection leading to changes in diet.

A check was made to find out if there were differences in texture judgments, preferences, and actual consumption of 16 different foods between the SDA group and a control group. Foods of different consistencies were chosen to represent a wide range in diets and the subjects scored the ease of mastication for each food group. On the whole, no significant differences were found between the groups.

Other studies have shown that patients may compensate for posterior tooth loss by chewing longer,[28] by swallowing larger food particles, or by selecting a softer diet.[29] Although some investigations have indicated improved chewing efficiency with a distal extension removable partial denture,[27,28] a study by Gunne indicated that no major changes in diet were to be expected.[29]

Age and the Effects of the Loss of Teeth on Diet and Nutrition

The practical implications of recognizing different functional levels for individual patients before developing and instituting treatment may be the most significant concept in the SDA rationale.

One study reported that with appreciable tooth loss there is a related decline in masticatory function, resulting in a compromised nutritional state.[30] However, the theory of prosthodontic rehabilitation improving masticatory function and limiting the risk of severe nutritional problems has not been proven.

Studies have indicated that the distribution of opposing contacts is more important to patients than the relation between missing teeth and function. A study by Smith and Sheiham also showed that only 42% of those clinically assessed as needing treatment felt they required treatment, and only 19% had tried to obtain it.[31]

Mandibular Dysfunction Syndrome and Posterior Edentulism

Costen in the year 1935 noted that ear and sinus symptoms manifesting as facial pain were often related to disturbed function of the mandibular joints, thus creating the illusion that temporomandibular joint disturbances could be adequately treated by dental intervention alone. This led to widespread alteration of occlusal vertical dimension by dentists but not always with benefit to the patient.

Sicher recognized the shortfalls of radical occlusal alteration and protested that there was no anatomical support for this reasoning.[32] Current opinion suggests that the cause of temporomandibular joint dysfunction is multifactorial and not solely related to occlusal imperfections.[33]

In most instances the mandible functions as a Class 3 lever in the mid-saggital plane, the tripodal bracing effect of the condyles, and the teeth being in balance around the bilateral pull of the masticatory muscles. Thus a wider spread of occlusal forces could, in essence, reinforce this braced position. An examination of the alignment of the major closing muscles will show that the combined vector of forces of the masseteric bellies, the medial pterygoid, and the superficial temporalis exert an anterior superior closing force,[32] which is borne mostly by the bracing of the condyles against the anterior slope of the articular eminence and the interlocking of cusps and vertical overlap of the anterior teeth. Theoretically, the distance of these teeth from the envelope of closing muscles places much of this closing force on the condylar elements; however, research has shown no increase in the incidence of temporomandibular dysfunction in patients with SDA (Fig 5).[34]

Conclusion

Dentists' attitudes to the SDA concept have shown that the concept is accepted; however, a rational treatment planning sequence for the SDA based on a thorough evaluation of functional, esthetic, and psychological needs is not widely practised.[35]

Much of the opposition to complete restoration of the shortened dental arch has focused on the deficiencies inherently present in removable partial denture prostheses. Quality-of-life assessments have shown that improvements in function

A.

B.

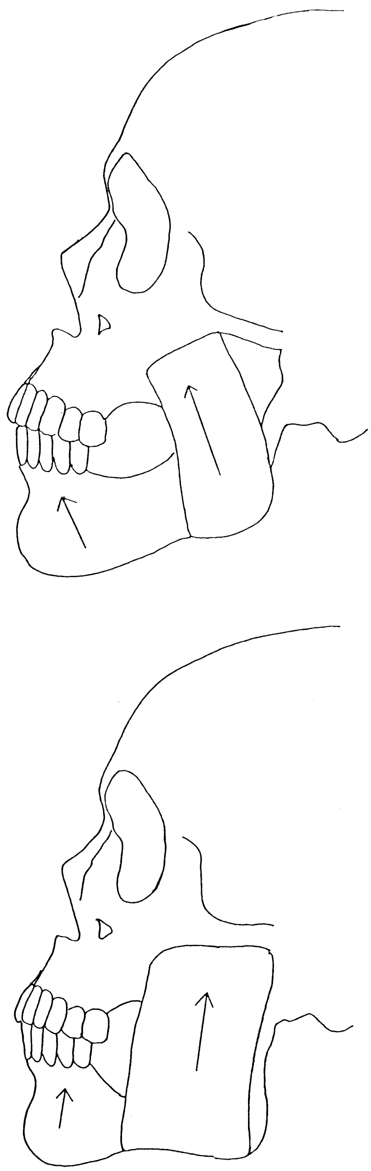

Figure 5. Representation of the lever systems acting on the shortened dental arch. (A) Class II arch relationships often result in a significant anterior component to the muscular force. (B) Class III arch relationships result in axial direction of muscular force.

are not always associated with the use of removable prostheses.[36] Studies have indicated that as much as 60% of the population of mandibular RPD wearers is dissatisfied with their prostheses.[37] The long-term success of implant-borne prostheses to rehabilitate the partially and completely edentulous jaw has provided the profession with an alternative to removable prostheses[38]; however, this treatment may not always be possible due to local and systemic factors.

The cost of new technology in dentistry places a primary burden on the patient and a widespread recourse to managed care has placed severe limitations on the number of patients that may be able to avail themselves of the treatment. The question of the shortened dental arch becomes less and less one of effectiveness of treatment and more of a financial decision.

As prosthodontists, we often spend hours agonizing over minor variables in the execution of treatment. Equally important, as health professionals, it is imperative that we evaluate our patients as individuals, requiring more than just a dentition but a well-functioning, if theoretically incomplete, masticatory system that serves to fulfill each person's varying needs.

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