

The shortened dental arch: A review of the literature

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The functional demands of patients are highly variable and individual, requiring dental treatment to be tailored to the individual's needs and adaptive capability. The World Health Organization indicates that a functional, esthetic, natural dentition has at least 20 teeth, while the literature indicates that dental arches comprising the anterior and premolar regions meet the requirements of a functional dentition. The English-language peer-reviewed literature pertaining to the short dental arch (SDA) was identified through the Medline search engine covering the period between 1966 and the present and critically reviewed. This treatment option for the partially dentate patient may provide oral functionality, improved oral hygiene, comfort, and, possibly, reduced costs. (J Prosthet Dent 2004;92:531-5.)

To provide care for the partially-dentate or edentulous patient, the dentist must consider a number of factors, such as oral functionality, vertical dimension, occlusion, maintenance of hard tissue, and temporomandibular joint health, as well as patient comfort. The weight accorded each factor varies with the patient and the proposed treatment, but a question that remains is how many teeth are needed to satisfy functional demands. *Oral functionality* is defined in this article as the maintenance of masticatory ability and efficiency while preserving the health of soft and hard tissues.¹⁻³

For the partially dentate patient with several posterior teeth, the dentist may design a fixed or removable partial denture (FPD or RPD), incorporating 1 or more natural teeth. When the first or second molars are present, they are usually incorporated into the prosthesis design, but it is unclear whether this is necessary to maintain oral functionality. In other words, should the occlusal table be extended to the first and second molar teeth? A longer occlusal table may be achieved with implant-supported restorations by posterior placement of the implant, but this usually is limited to the first molar position. With implant-supported restorations, it is possible to achieve posterior occlusion by cantilever extensions, although this should be limited to 6 to 8 mm in the maxilla and 10 mm in the mandible.⁴ It is unclear from the dental literature whether this extension is either necessary or justified.

Dentists replace missing, damaged, and severely decayed teeth by fixed or removable prostheses to restore or improve masticatory function. There is a fundamental question in any treatment plan, namely, the desirable/mandatory length of an occlusal table. There have been various references in the literature to the concept of the short dental arch (SDA) as a defined treatment option for the partially dentate patient. While many dentists may accept that restoring the complete dental arch is not always necessary, there still is the need to provide

the patient with an affordable and functional treatment, a need satisfied by the short dental arch. The English-language, peer-reviewed literature pertaining to the short dental arch (SDA) was identified through the Medline search engine covering the period between 1966 and the present and critically reviewed. This treatment option for the partially dentate patient offers the benefits of oral functionality, improved oral hygiene, comfort, and possibly reduced costs.

Oral functionality

The literature indicates that masticatory ability is closely related to the number of teeth, and there is impaired masticatory ability when the patient has less than 20 well-distributed teeth.^{5,6} In this context, the shortened dental arch (SDA) may be defined as having an intact anterior region but a reduced number of occluding pairs of posterior teeth.⁷

In 1992, the World Health Organization stated that the retention, throughout life, of a functional, esthetic, natural dentition of not less than 20 teeth and not requiring recourse to prostheses should be the treatment goal for oral health.⁸ It is not possible, however, to quantify the minimum number of teeth needed to satisfy functional demands because these demands vary from individual to individual. Furthermore, both dental and financial considerations strongly influence the treatment plan, and, in fact, dental arches comprising the anterior and premolar regions meet the requirements of a functional dentition.^{8,9} It follows that the replacement of missing molar teeth by cantilevers, resin-bonded fixed partial dentures, implant-supported prostheses, or distal extension removable partial dentures may amount to over-treatment for patients with shortened dental arches.

Masticatory efficiency

Masticatory efficiency and masticatory ability are important components of oral functionality, but patient adaptation to changes in dental arch length with progressive loss of teeth is critical to successful treatment. The literature on masticatory efficiency and masticatory

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ability over the past 50 to 60 years can be separated into 2 broad categories, subjective and objective evaluations.¹ Subjective masticatory function or masticatory ability usually is evaluated through interviews with patients assessing their own masticatory functionality. Objective evaluation of masticatory function or masticatory efficiency commonly involves measurement of the patient's ability to grind food. Overall, the literature indicates that masticatory ability closely correlates with the number of teeth and is impaired when there are fewer than 20 uniformly distributed teeth in the mouth.⁶

The correlation between the dental arch length and masticatory efficiency is infrequently addressed in the literature. An early study involved a cross-sectional clinical investigation of 118 patients separated into 6 groups according to the length and symmetry of the shortened dental arch.⁷ Two patterns of change in oral function were identified. In 1 group, masticatory efficiency changed slowly until the dentition had been reduced to 4 occlusal units and, thereafter, decreased rapidly. In the second group, masticatory efficiency changed progressively at a quasi-uniform rate. The authors suggested that there is sufficient adaptive capacity for patients to maintain adequate oral function in shortened dental arches provided at least 4 occlusal units remain, although these must be symmetrically placed.

Another study compared patient perceptions related to masticatory efficiency in 43 subjects with SDAs with the findings from 54 patients with complete dentitions. The results indicated that while masticatory function, food perception, food selection, and actual food consumption were affected for SDA patients, the perceived reduction was acceptable to the patients.¹⁰

In another study, the oral functionality for patients with shortened dental arches was compared with that for patients with dental arches lengthened by distal extension removable partial dentures.¹¹ No significant differences were found in the oral functionality of subjects with SDAs and those who wore RPDs. Overall, the findings of the study suggested that oral functionality was not improved for SDA patients when provided with a distal extension RPD, and most complaints appeared to be related to esthetics due to missing posterior teeth.

A more recent study⁶ compared the masticatory abilities of Tanzanian subjects with shortened dental arches to those of adults with complete dental arches. The SDA patients had 0 to 8 pairs of occluding posterior teeth and differed in arch length and arch symmetry. Masticatory ability was assessed subjectively through perceived difficulties in masticating 20 common Tanzanian foods. Patients with very shortened arches, 0 to 2 pairs of occluding premolars, had a 95% to 98% prevalence of complaints and the greatest difficulties in mastication. In contrast, the prevalence of complaints was only 3% to 5% for subjects with intact premolar regions and at least

1 pair of occluding molars. Other categories of subjects, that is, those with different numbers of premolar and molar teeth, reported an intermediate volume of complaints (33% to 54%). The study noted that there was an inverse relationship between the perceived difficulty of mastication and the decrease in the number of pairs of occluding teeth; thus, for example, subjects with 0 to 2 pairs of occluding premolars had severely limited masticatory ability. Likewise, subjects with asymmetric arches and unevenly distributed teeth reported greater masticatory difficulty than subjects with more complete dental arches. Any differences in masticatory ability were exacerbated with harder foods.

Overall, if the premolar regions are intact and there is at least 1 pair of occluding molars, the authors concluded that an SDA does not impair masticatory efficiency. In contrast, there is severely impaired masticatory ability when the patient has a reduced number of occluding premolars and/or asymmetric arches, especially with hard foods.⁵

It has been reported by some authors, however, that SDAs do not lead to alterations in food selection although patients only have sufficient masticatory ability when 20 or more "well distributed" teeth remain, that is, when anterior and premolar teeth are present.¹² Thus, impaired masticatory ability and associated changes or shifts in food selection are manifested only when there are less than 10 pairs of occluding teeth.¹²

Prosthodontic considerations

Prosthodontic considerations in patient treatment include occlusal stability, establishing the correct vertical dimension, and preserving the health of the soft and hard tissues as well as that of the temporomandibular joint. While occlusal stability can be defined as the absence of the tendency for teeth to migrate other than the normal physiologic compensatory movements occurring over time,^{13,14} a better definition may be the stability of tooth positioning relative to its spatial relationship in the occluding dental arches.¹⁵ Occlusal stability is determined by a number of factors, including periodontal support, the number of teeth in the dental arches, the interdental spacing, occlusal contacts, and tooth wear. Typically, there is tooth mobility, tooth migration, and supra-eruption of unopposed teeth when 1 or more teeth are missing from an arch. Distal tooth migration occurs in SDAs, and this may result in an increased anterior load which, in turn, increases the number and intensity of anterior occlusal contacts as well as the interdental spacing.¹⁶ Such effects may be exacerbated when unopposed teeth and lone-standing teeth have inadequate periodontal support. Likewise, tooth migration can cause changes in the vertical and horizontal overlap, occlusal wear, and loss of posterior support, among other effects.

Although it is widely believed that changes in occlusal balance cause tooth movement, migration, and supra-eruption, few studies have addressed the relationship between shortened dental arches and occlusal stability. Occlusal stability is thought to be reduced with extremely short dental arches, that is, only 0 to 2 pairs of occluding premolars. While occlusal stability is reported to be greater with longer dental arches, that is, 3 to 4 occluding units, older patients generally experience increased changes in occlusal integrity.¹⁵ Overall, SDAs comprising anterior and premolar teeth satisfy oral functional demands and show similar vertical overlap and occlusal tooth wear patterns to those found with complete dental arches.¹⁶ While patients with SDAs have more interdental premolar spacing, greater occlusal contact of anterior teeth, and lower alveolar bone scores (that is, the alveolar bone height at the distal surface of each premolar¹⁵), the differences in dentition and occlusal characteristics from those of complete or longer dental arches appear to change little over time.¹⁶ This suggests that the SDA, in fact, is characterized by long-term occlusal stability.

Few studies are reported on the prevalence of temporomandibular joint (TMJ) problems in adults with shortened dental arches. A study compared SDA subjects with an intact anterior region and 0 to 8 posterior occluding pairs of teeth with a control group having complete dental arches.¹⁷ The study reported a greater prevalence of joint sounds with subjects having only unilateral posterior support and those with no posterior support. However, there were no differences in pain, mandibular mobility, maximum mouth opening, or clicking/crepitation of the joints for the SDA and control groups. It was noted, however, that tooth wear increased significantly with decreased posterior support. While there was no evidence that SDAs provoke TMJ problems, it was noted that the risk for pain and joint sounds increased when unilateral or bilateral posterior support is missing.¹⁷

Another study addressed the question of whether SDAs could cause functional overloading of the teeth and TMJ, effects possibly leading to periodontal disease and TMD.¹⁸ Electromyographic masticatory muscle studies were used to calculate occlusal forces and joint loads using a finite element jaw model and compared these values with actual measured occlusal forces. While the occlusal force on each tooth increased with missing molar occlusion, there appeared to be an overall decrease in joint loads, although the occlusal force per root surface area was always greatest on the most posterior tooth. There were no indications that an SDA can cause overloading of the TMJ or the teeth, suggesting that neuromuscular regulatory systems are efficient in controlling the maximum clenching force under various occlusal conditions.¹⁹

Patient comfort

Patients must adapt functionally and psychosocially to dentures, and some may never achieve this goal. As a result, while the inserted prosthesis may satisfy all objective criteria regarding fit, quality, and appearance, a patient may be dissatisfied and occasionally intolerant of a denture based on subjective evaluation of comfort, functionality, and esthetics. Since patient evaluation criteria are difficult to quantify, the correlation between dentist and patient opinions of dentures tends to be poor.¹⁹⁻²¹ These differences between clinician and patient perception are important when the SDA patient is to receive treatment.

Few clinical studies have assessed objectively patient oral comfort, typically the absence of pain or distress, masticatory ability, and the appearance of the dentition, in terms of arch length. When the oral comfort for SDA patients was compared with that for SDAs and distal extension RPDs and for subjects with complete dental arches, no significant differences were found between the 3 groups with respect to pain or distress, and only 8% of the SDA subjects reported impaired masticatory ability.²² It was noted that 20% of the SDA and RPD patients were dissatisfied with the RPDs, and many patients stopped wearing the RPD over longer periods. While an SDA can compromise oral comfort to a small extent, it was still acceptable to the patients, and there were no indications that providing distal extension RPDs enhanced oral comfort for SDA patients.²²

Another study, based on patient questionnaires, found that when bilateral RPDs are used to restore shortened mandibles, not only did patients prefer not to wear them, but there were indications of adverse effects on the remaining teeth despite an improved masticatory ability.²³ Patients provided with distal cantilever resin-bonded FPDs to restore the shortened mandibular dental arch reported both better masticatory ability and a greater overall satisfaction than the RPD patients.²³

Clinical opinions regarding SDAs

Many patients with shortened dental arches receive treatment, but there is no formal recognition of the SDA as a component in clinical treatment, and few papers in the literature addressing clinical attitudes to the SDA in current therapy. A questionnaire administered by British authors indicated that the SDA is widely accepted but not widely practiced in the United Kingdom.²⁴ The outcome of SDA therapy (SDAT) was found to be acceptable in approximately 82% of patients in terms of patient oral function, comfort, and well-being. Some 88% of respondents to the questionnaire reported prescribing SDAT during the previous 5 years, although 37% of the participants reported a need to extend shortened dental arches following SDAT.

Another questionnaire-based study evaluated the attitudes and application of the SDA concept in clinical practice of the 64 restorative dentistry faculty members at the Nijmegen School of Dentistry in The Netherlands.²⁵ There was a 64% response, and all but 1 of the respondents viewed the SDA concept as having a useful place in clinical practice. Although the respondents indicated clinical use of the SDA concept in more than 10% of patients, the outcome of SDA management was generally satisfactory or at least sufficient. This appeared to be particularly true for special categories of patients, such as those who were medically compromised. Overall, the findings indicated that the SDA concept has a role in contemporary clinical practice.

Treatment options and alternatives

As the number of remaining teeth decreases, considerations of oral functionality, prosthodontic treatment, and patient comfort become increasingly important. In other words, does the shortened dental arch and reduced food platform area compromise masticatory ability and/or efficiency or adversely influence food selectivity? While restoration of the complete dental arch (that is, up to and including the second molars) is desirable, this treatment option may not be practical or possible for every patient, while occasionally being prohibited by financial constraints. Furthermore, complete dental arch restoration may be inadvisable for compromised and high-risk patients such as immunosuppressed patients and those undergoing radiotherapy, chemotherapy, or both. Nevertheless, the question remains as to what is an adequate and reasonable standard of treatment for the partially dentate patient with the obvious corollary of whether the cost of treatment is justified by the perceived and/or actual clinical outcome.

Acceptable oral health throughout life is the retention of a functional, esthetic, natural dentition of not less than 20 teeth and not requiring recourse to prostheses. This implies that adult patients have adequate oral functionality when the most posterior teeth are the second premolars. The concept of the shortened but functional dental arch addresses this issue, and the literature indicates that the SDA does not contradict current occlusion theories while offering some important advantages. In particular, the SDA protocol decreases the emphasis on restorative treatments for the posterior regions of the mouth. In other words, the SDA may avoid the risk of overtreatment of the patient while still providing a high standard of care and minimizing cost.

The SDAT protocol terminates the occlusal platform at the second premolar region. This may be beneficial for the implant patient since no posterior implants are needed, thereby simplifying both the surgical implant placement and its restoration. Likewise, the SDA proto-

col may be beneficial for the high-risk patient in that restricting the dental arch length reduces the treatment regimen without compromising oral functionality.

SUMMARY

The literature indicates that dental arches comprising the anterior and premolar regions meet the requirements of a functional dentition. However, functional demands, and the number of teeth to satisfy such demands, vary with the individual and, consequently, dental treatment must be tailored to each individual's needs and adaptive capability. By offering the partially dentate patient a treatment option that ensures oral functionality, improved oral hygiene, comfort, and possibly reduced costs, the shortened dental arch (SDA) treatment approach appears to provide an advantage without compromising patient care. The SDA concept does not contradict current occlusion theories and appears to fit well with the problem-solving approach favored in modern dentistry. Advocating the SDA offers some important advantages, one of which may be a decreased emphasis on restorative treatments for the posterior regions of the mouth.

REFERENCES

1. van der Bilt A, Olthoff LW, Bosman F, Oosterhaven SP. The effect of missing postcanine teeth on chewing performance in man. *Arch Oral Biol* 1993;38:423-9.
2. Witter DJ, van Palenstein Helderma WH, Creugers NH, Kayser AF. The shortened dental arch concept and its implications for oral health care. *Community Dent Oral Epidemiol*. 1999;27:249-58.
3. Witter DJ, De Haan AF, Kayser AF, Van Rossum GM. A 6 year follow-up study of oral function in shortened dental arches. Part I: Occlusal stability. *J Oral Rehabil* 1994;21:113-25.
4. Rodriguez AM, Aquilino SA, Lund PS. Cantilever and implant biomechanics: a review of the literature, Part 2. *J Prosthodont* 1994;3:114-8.
5. Rosenoer LM, Sheiham A. Dental impacts on daily life and satisfaction with teeth in relation to dental status in adults. *J Oral Rehabil* 1995;7:4469-80.
6. Sarita PT, Witter DJ, Kreulen CM, Van't Hof MA, Creugers NH. Chewing ability of subjects with shortened dental arches. *Community Dent Oral Epidemiol* 2003;31:328-34.
7. Kayser AF. Shortened dental arches and oral function. *J Oral Rehabil* 1981;8:457-62.
8. World Health Organization. Recent advances in oral health. WHO Technical Report Series No. 826. WHO, Geneva; 1992. p. 16-17.
9. Witter DJ, De Haan AF, Kayser AF, Van Rossum GM. A 6-year follow-up study of oral function in shortened dental arches. Part II: Craniomandibular dysfunction and oral comfort. *J Oral Rehabil* 1994;21:353-66.
10. Aukes JN, Kayser AF, Felling AJ. The subjective experience of mastication in subjects with shortened dental arches. *J Oral Rehabil* 1988;15:321-4.
11. Witter DJ, van Elteren P, Kayser AF, van Rossum MJ. The effect of removable partial dentures on the oral function in shortened dental arches. *J Oral Rehabil* 1989;16:27-33.
12. Witter DJ, Cramwinckel AB, van Rossum GM, Kayser AF. Shortened dental arches and masticatory ability. *J Dent* 1990;18:185-9.
13. Mohl ND. Introduction to occlusion. In: Mohl ND, Zarb GA, Carlsson GE, Rugh JD, editors. *A textbook of occlusion*. Chicago: Quintessence; 1988. p. 15-23.
14. Sarita PT, Kreulen CM, Witter DJ, van't Hof M, Creugers NH. A study on occlusal stability in shortened dental arches. *Int J Prosthodont* 2003;16:375-80.

15. Witter DJ, Creugers NH, Kreulen CM, de Haan AF. Occlusal stability in shortened dental arches. *J Dent Res* 2001;80:432-6.
 16. Witter DJ, van Elteren P, Kayser AF. Migration of teeth in shortened dental arches. *J Oral Rehabil* 1987;14:321-9.
 17. Sarita PT, Kreulen CM, Witter D, Creugers NH. Signs and symptoms associated with TMD in adults with shortened dental arches. *Int J Prosthodont* 2003;16:265-70.
 18. Hattori Y, Satoh C, Seki S, Watanabe Y, Ogino Y, Watanabe M. Occlusal and TMJ loads in subjects with experimentally shortened dental arches. *J Dent Res* 2003;82:532-6.
 19. Kuboki T, Okamoto S, Suzuki H, Kanyama M, Arakawa H, Sonoyama W, et al. Quality of life assessment of bone-anchored fixed partial denture patients with unilateral mandibular distal-extension edentulism. *J Prosthet Dent* 1999;82:182-7.
 20. Silverman S, Silverman SI, Silverman B, Garfinkel L. Self-image and its relation to denture acceptance. *J Prosthet Dent* 1976;35:131-41.
 21. Van Waas MA. Determinants of dissatisfaction with dentures: a multiple regression analysis. *J Prosthet Dent* 1990;64:569-72.
 22. Witter DJ, Van Elteren P, Kayser AF, Van Rossum GM. Oral comfort in shortened dental arches. *J Oral Rehabil* 1990;17:137-43.
 23. Allen PF, Witter DF, Wilson NH, Kayser AF. Shortened dental arch therapy: views of consultants in restorative dentistry in the United Kingdom. *J Oral Rehabil* 1996;23:481-5.

24. Jepson N, Allen F, Moynihan P, Kelly P, Thomason M. Patient satisfaction following restoration of shortened mandibular dental arches in a randomized controlled trial. *Int J Prosthodont* 2003;16:409-14.
 25. Witter DJ, Allen PF, Wilson NH, Kayser AF. Dentists' attitudes to the shortened dental arch concept. *J Oral Rehabil* 1997;24:143-7.

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