Minimal Intervention Prosthodontics: Current Knowledge and Societal Implications

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Key Words

Minimal intervention · Contraindications · Limitations ·
Prosthodontics · Acrylic resin toxicity · Human resources

Abstract

Minimal intervention prosthodontics can be considered a treatment option for a country's overall dental health care plan. Prosthodontics can cover a range of increasingly aggressive treatment interventions depending on the severity and progression of the disease. The 'shortened dental arch' concept is a minimal treatment intervention approach that has been advocated for a wide range of partially edentulous patients. This concept favors limited prosthodontic intervention to achieve patient-perceived acceptable function levels in the presence of multiple missing teeth. The implementation of minimal interventions should be balanced by considering risk-to-benefit ratios, as well as the consequences of nonintervention or low-level prosthodontic interventions. The 'nonintervention' approach and low-level prosthodontic interventions have inherent consequences and well-documented risks; professional ethics dictate that a practitioner present these risks as well as the known benefits of all treatment options. Developing countries are under significant pressure to effectively uti-

lize limited resources, increase skilled human resources, provide advanced levels of care to very large numbers of patients and plan for the future dental health care of their society. Many developing countries are prime candidates for inadvertent abuse and misappropriation of prosthodontic materials, treatment modalities and human resources in trying to provide cost-effective prosthodontic care. A developing country can learn from the mistakes that developed countries have made in the past and use the evidence from these experiences to plan for a better future state of dental health for their society.

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Dental Health Continuum

The purpose of this literature review is to evaluate the appropriateness of minimal prosthodontic intervention among patients with varying degrees of natural tooth loss or destruction of coronal tooth substance. Tooth loss occurs in both developed and newly developing countries as a result of dental caries, periodontal disease, trauma, neoplastic disease, developmental maladies and environmental factors. This review summarizes the literature that supports or refutes the 'minimal treatment concept' with emphasis on important gaps in this body of knowledge.

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Table 1. The total average cost (irrespective of payment system) and 50% survival time in years (with reference to the available literature) of replacing one tooth according to the treatment approach

Treatment	Indexed cost	50% survival time, years	Cost/year of service ¹	Cost rank ²
Single-tooth implant	1.6	20 [2, 3] ³	0.080	1
Acrylic-resin RPD	0.2	3 [4]	0.067	2
Metal-frame RPD	0.5	8 [4]	0.063	3
Adhesive 3-unit FPD	0.5	10 [7]	0.050	4 ⁴
Metal-ceramic FPD	1.0	20 [5, 6]	0.050	4 ⁴

The 3-unit metal-ceramic FPD is used as index 1 in comparison with other alternatives, and the costs are given for Denmark, the Netherlands and Sweden in 1994 (expansion of Jemt et al. [1]).

¹ Indexed cost divided by 50% survival time (years).

² Rank of cost/year: 1 = most expensive, 4 = least expensive.

³ Extrapolation based on available clinical studies [2, 3].

⁴ Two procedures tied for least expensive procedure cost/year.

A patient's oral health status can be categorized along a continuum from optimal dental health through various levels of gradually worsening dental deterioration. This continuum extends from the dentate adult with a complete complement of natural teeth to the totally edentulous state. Deterioration can continue further, from the edentulous state to an end-state of severe residual ridge resorption. Advancing age and worsening medical conditions can complicate all of the various stages of dental health deterioration.

Rate of Disease versus Normal Age-Related Changes

Dentition wears down as a result of loss of enamel and dentin during mastication and other physiologic functions throughout the life cycle. Any discussion of the incidence of a disease and its relative rate of progression in a society should be compared to the normal rate of breakdown as a result of age in an otherwise healthy population. Because of increasing life expectancy throughout the world, a society must evaluate dental disease in the senior population who remained free of dental complications but became threatened with compromised dentitions late in life. Most societies will continue to experience growth in the population group over the age of 65 years, and this cohort will have increasingly complex dental needs.

The rate and the state of oral disease in a patient at any moment in time must be balanced with a benefit-to-risk ratio when choosing a treatment procedure. Every prosthodontic intervention carries a benefit-to-risk ratio that must be compared with the rate of progression of the disease, the current state of the disease and any risks associated with 'nonintervention treatment'. To meet those

considerations, various treatment options are possible: (1) no treatment, (2) one or more low-level prosthodontic interventions or (3) one or more advanced-level prosthodontic interventions. For example, if a mandibular first molar tooth is lost, the clinician might compare the consequences of nontreatment to a low-level prosthodontic treatment intervention (e.g. transitional removable prosthesis) to an advanced-level prosthodontic intervention (e.g. metal-ceramic fixed prosthesis).

Based on published reports [1–6], Owall et al. [7] concluded that a transitional removable partial denture (RPD) has a 3-year 50% survival rate compared to 20 years for the metal-ceramic fixed partial denture (FPD). A cost comparison of these two procedures is illustrated in table 1. An initial evaluation of cost reveals that the transitional RPD is less than half the cost of an FPD. However, the data in table 1 demonstrate a significant 'reduced cost per year' for the more advanced prosthodontic intervention, the metal-ceramic FPD. Thus, the patient and the society can experience a higher-valued service at a reduced cost with the FPD. In addition to the cost factor analysis, there are negative consequences associated with nontreatment and the low-level transitional RPD that will be discussed further.

Societal Influences on Need versus Demand for Prosthodontic Care

Each society must determine the current overall dental health of the population when deciding on the desired future level of dental health and how to achieve it. If the societal treatment needs are high, with a low supply of health care providers, the government must consider

facilitating infrastructure development to foster the maturation of a developing dental health care system. Without governmental facilitation the maturation process will be slow, particularly if there is an absence of existing skilled personnel or attractive incentives [8–14].

To complicate the evolution-maturation process, the needs and demands of professional services within a society must be considered. Treatment needs do not necessarily translate directly into demand for all types of care, as shown in studies of different population groups within the USA. Strauss [15] studied large numbers of African-Americans' feelings about their present dental health status compared to past sentiment using a survey instrument called the Dental Impact Profile. This study reported that many African-Americans were happier in their edentulous state with prostheses than they were in their previous dentate condition; these findings were in contrast to those of the Caucasian counterparts. Strauss revealed distinct patterns of dental health care utilization and patient self-perceived expectations based on demographic factors, race, culture and socioeconomic status. These findings demonstrate that variations among different population groups within the same society must be taken into account in developing countries when planning health care delivery systems.

Certain societies may place a very low priority on the dental health of their population with little or no assignment of governmental resources to facilitate or provide care to address this need. Such a society may emphasize individual responsibility with the expectation that the private resources of citizens would be used to meet dental needs. Obviously, a developing country may not realistically expect its population to be able to afford dental care on their own. If a developing nation's society has a relatively poor state of dental health, prosthodontic needs will vary, and the objective of national oral health care would be to treat the greatest number of citizens with a realistic resource allocation.

Prosthodontic Care Delivery and Human Resource Issues

A society's need for prosthodontic care is balanced by its demand for this care; the demand, in turn, influences the supply of technical and professional human resources in the health care system. Ideally, a complete health care system would include an adequate number of trained prosthodontic specialists and dental laboratory technicians. Owall et al. [7] illustrated the obstacles encountered in developing nations when attempting to provide this complex level of care because of human resource limita-

Table 2. Countries with legally accepted denturism, based mainly on information courtesy of the Fédération Dentaire Internationale/World Dental Federation, 1990 [1]

Country	Number of dentists	Number of denturists
Australia	6,897	607
Barbados	34	3
Canada	13,623	2,700
China (People's Republic)	11,044	400
Denmark	5,100	550
Finland	4,225	350
Iran	3,500	2,000
Kiribati	1	2
Morocco	170	2,000 ¹
The Netherlands	7,000	200
Pakistan	2,127	7,000
USA ²	12,000	350
Vietnam	1,594	1,000

¹ Unqualified dentists who fit dentures.

² Ariz., Colo., Idaho, Me., Md., Oreg., Wash. (total for 7 of 50 states).

tions. In the cited countries, needs were very high, but the technical expertise available was very low; improvement in the situation would require many years of infrastructure development by educational institutions, government investment and the society's sustained demand.

In a study of developing countries in Africa, Ana [9] reported general practitioner-to-population ratios of 1 to 111,000 in Senegal and 1 to 1,935,000 in Chad Republic. The sheer magnitude of the patient population with high prosthodontic treatment needs can overwhelm a health care system and preclude even minimal prosthodontic intervention. The central problem facing many such societies is a minimal number of professional caregivers coupled to a society with tremendous treatment needs.

Numerous health care delivery systems have tried to expand the capabilities of paraprofessional personnel to make increased services available and decrease governmental costs. One major area within dentistry in which this has been attempted is through the expanded duties of dental technicians. This system modification has allowed dental technicians to provide direct patient care as 'denturists' as well as perform the laboratory fabrication procedures for complete and partially removable prostheses. Table 2 lists countries where this has been attempted [7]. Some advanced countries, such as Canada and the Netherlands, have implemented various forms of 'denturism'

in the hope of reducing the costs of prosthodontic care. This change in scope of practice among the dental care delivery team has not been as widespread in the USA. The greatest number of studies of this phenomenon in the prosthodontics literature represents the Canadian experience [16–34].

Although controversial, the data suggest an apparent general trend of lower-quality prostheses, increasing costs of other treatments, such as periodontal procedures, and an increased rate of retreatment with lower patient satisfaction. A developing country must carefully evaluate this health care approach with consideration of the negative results documented in the literature.

Societal Prosthodontic Care Planning

A developing country must view prosthodontic care for the population according to three distinct time frames when planning a dental health care strategy. The time frames include: (1) immediate prosthodontic treatment needs in the first 5 years; (2) the intermediate period of 5–20 years and (3) the long-term period of greater than 20 years. The immediate period of the first 5 years will inevitably be the most difficult, with very high treatment needs and minimal resources.

During the first time frame, prioritization should allocate resources to the most deserving and serious patient conditions. Primary resource allocation can be assigned to treat completely edentulous patients first, due to the significant dental handicap endured by these individuals and with relatively low treatment cost to society. Subsequent priorities can be incrementally assigned to other patients according to the country's resources and perceptions of oral health. Owall et al. [7] have cited Swedish National Dental Insurance data from 1977 demonstrating a disproportionate advanced level of care to a small percentage of the population. Thus, a disproportionate allocation of resources is common even in the socialized systems of developed countries with highly advanced health care systems.

Intermediate and long-term plans should reap the rewards of significant changes in the population's prosthodontic treatment needs as a result of preventive measures instituted in earlier years. The preventive measures for caries and periodontal disease reduction will reduce the need among the population for prosthodontic care. However, a careful health care planner should avoid overly optimistic expectations from preventive measures. In 1984, Stamm [35] suggested that prevention of periodontal disease has been poor in both developed as well as developing countries. However, once the population has

reached this phase, the development and maturation of the dental profession should have progressed to the point where it is more capable of managing the population's reduced prosthodontic treatment needs.

Clinical Decision Analysis and Informed Consent

To begin the process of assessment, it will be assumed that preventive and/or conservative/operative dentistry procedures have been totally absent or have failed to halt the progression of the process of tooth decay or loss. The first stage along the continuum of dental breakdown might be the large carious lesion with irreversible pulpal pathology in an otherwise intact dentition or advanced periodontal destruction of the supporting structures of a single tooth.

A clinical decision analysis [36, 37] would include two basic options for treatment of the single affected tooth: extraction or restorative therapy with endodontic and periodontal adjunctive therapy, respectively. In a health care delivery system with minimal treatment options, this tooth would be extracted with no further treatment because advanced therapeutic procedures involve cost factors many times greater than that of the single-visit extraction.

The standard of care in advanced, industrialized countries [36, 37] should be used as a starting point for discussion of this aspect of patient management. Due to legal and ethical considerations in the developed countries, the standard of care demands that the clinician provider should present all relevant treatment options, regardless of their resource allocation, complexity, availability or location. This ethical obligation can be somewhat general and may not be within the capabilities of the individual provider but may include a referral recommendation to a tertiary level of care. The nonintervention and minimal prosthodontic intervention (low-level prosthodontic treatment) are two treatment options that should always be accompanied with an explanation of hazards, limitations and risk.

Shortened Dental Arch Concept

The loss of some natural posterior teeth, and the study of related maladies or side effects, has become known in the literature as the shortened dental arch (SDA) concept. A significant number of citations have appeared in the prosthodontic literature related to SDA and its consequences [38–53]. This body of literature has introduced and evaluated the SDA treatment goal of retaining a limited number of natural teeth without prosthetic replacement. These citations have documented the patient feel-

ings and levels of satisfaction, as well as undesirable sequelae as compared to patients with prosthetically restored dentitions. The literature suggests that a minimum of four pairs of posterior tooth contacts are necessary for adequate masticatory function, although the specific combination of contacting teeth has not been recommended.

Reduction of Chewing Efficiency

As a result of the initial minimal intervention procedures of SDA tooth extraction, degradation of dental health is not necessarily halted: the literature has demonstrated varying consequences of tooth loss which further compromise a patient's long-term dental health. The first consequence of the loss of a single tooth is a significant drop in site-specific chewing efficiency.

In the literature [42–46, 54–120], chewing efficiency has been quantified by several different methods, along with other factors such as the swallow threshold and salivary output. Measurement of chewing efficiency remains a relatively controversial topic due to methodological variability. The literature reveals two major methods of assessment: the participants' feelings about their ability to masticate and measures of the pulverization of a test food in a set time period. These two methods can lead to vastly different results; patients may feel that they can masticate adequately with their compromised dentitions but demonstrate a greatly reduced ability to pulverize the test food.

A loss of only the mandibular first molar tooth in a young, healthy dentate patient can cause a 40% reduction in chewing efficiency [113]. Nonetheless, the SDA concept has been substantiated by studies of the participants' assessment that indicate they would be satisfied with the greatly reduced chewing efficiency that accompanies tooth loss [42–46, 120–124].

Tooth Changes with Adjacent/Antagonist Loss

Subsequent secondary tooth migration of the adjacent second molar into the edentulous space is a common side effect of first molar tooth loss. The opposing maxillary first molar often erupts because of the absence of its opposing occlusal contact. This positional shift can lead to furcation involvement, elongation of the bony segment and pseudoperiodontal pocket formation, as well as protrusive occlusal interferences in eccentric mandibular movements. Unfortunately, no evidence exists in the literature to help clinicians predict whether these common side effects of tooth loss will or will not occur. One recent study has suggested that molar shift is uncommon [125]. Nevertheless, correction of these compensatory changes

when they do occur requires tremendous resources compared to preventive prosthodontics at the time of tooth loss.

Tooth Wear Rate and Fracture

Tooth wear and fracture occur at some rate in normal function throughout life but appear to accelerate with advancing age. Johansson et al. [126] found a complex interaction between multifactorial etiologic factors and age. Tooth wear occurs at varying rates in patients based on the number of teeth, restoration material types, brushing activity and dietary considerations.

As the number of teeth lost increases, the wear rate to the remaining teeth also increase proportionately: the possible acceleration of this process is due to the overloading of remaining teeth. The increased load per tooth also causes abnormally high stress to the periodontal apparatus which can lead to cusp fracture. In a recently published study [125] on tooth wear and fracture rates in the USA, approximately one quarter of the study population had tooth fractures caused by normal function during a 24-month period. This type of worsening dental health demonstrates the acceleration of deterioration that can occur within a population and places further challenges on a developing country's planning strategy.

Loss of Vertical Dimension of Occlusion and Other Secondary Changes

As posterior teeth are lost, a decrease in vertical dimension of occlusion can occur in the partially edentulous patient. Excessive loading occurs on the remaining anterior teeth with secondary changes in anterior tooth position, periodontal support and mobility. A common intraoral structural change that accompanies loss of multiple posterior teeth is tongue enlargement due to increased function in chewing.

Transitional RPD

The Glossary of Prosthodontic Terms (GPT-7, 1999) [127, p 124] defines a transitional partial denture as 'a removable partial denture serving as an interim prosthesis to which artificial teeth will be added as natural teeth are lost and that will be replaced after postextraction tissue changes have occurred'. This prosthesis, generally, has the following attributes: wire clasp direct retainers, acrylic resin base and major connector components with artificial teeth. This type of prosthesis is classified as interim *only*, chiefly because of its lack of vertical support with poor load distribution, a lack of major connector strength and rigidity, and excessive tissue coverage. Because of

these three drawbacks, this type of prosthesis is designed for short-term use only, perhaps 3 months or less.

The lack of vertical support can cause excessive load distribution to the edentulous ridge area(s) instead of additional load distribution to as many remaining natural tooth abutments as possible. Additionally, the lingual aspects of many remaining natural teeth are covered to distribute the load to a wider area as well as provide additional direct retention in tooth undercuts. Another significant disadvantage to this type of prosthesis is additional thickness of acrylic resin material to make the major connector as rigid as possible. The combination of excessive bulk and additional tissue coverage contributes to significant potential adverse tissue effects.

Numerous studies have demonstrated the ill effects of different types of acrylic resin materials on epithelial cells of the gingival complex. A developing society should be extremely careful in utilizing this type of prosthesis as a minimal prosthodontic treatment intervention because of its well-documented negative dental health effects. This type of prosthesis may appear to require less societal resources with reduced clinician treatment time and only a preliminary irreversible hydrocolloid impression step. Often, the prosthesis is delivered at the next visit with a reduced laboratory cost because the costly fabrication of a cast metal framework is not required. No published studies have demonstrated data in the literature to support the superiority of this type of prosthesis compared with non-intervention or conventional RPD treatment.

Owall et al. [7] have cited studies [10–15] in the prosthodontic literature demonstrating the indexed cost and 50% survival rates for transitional RPD, RPD with a cast metal framework, various types of 3-unit FPDs and single-tooth endosseous implant restoration. The transitional RPD is 40% less expensive than a cast metal RPD, with a survival rate of 3 years based on data from several northern European countries. Initial evaluation of the data indicates that the transitional RPD appears to be the least expensive, with a 3-year survival rate. However, this cost analysis fails to point out that the 3-unit metal-ceramic FPD has a cost factor of only 5 times the transitional RPD prosthesis but a survival rate 7 times longer. The society would have to replace the transitional RPD approximately 7 times in the same period in 50% of the population with a 34% increase in cost. In addition, with each successive replacement of the transitional RPD, there is potential for further deterioration of the remaining dentition because of the factors previously discussed.

The literature [128–132] has shown the ill effects of the close proximity of the acrylic resin of the transitional

RPD to the free gingival margin. Porosity and water sorption foster bacterial colonization on the surface as well as within the material. Hayashi [132] has, with electron microscopy, demonstrated the accumulation of mineralized calculus on the intaglio surface of acrylic resin base material. This proclivity for bacterial colonization and mineral deposition in the form of calculus adjacent to the gingival tissues increases the insult to these tissues. Clinicians of developing countries should avoid utilizing transitional RPDs for prolonged periods in lieu of more advanced prosthodontic procedures, namely conventional RPD with cast metal framework or FPD.

Environmental Hazards and Health Care Planning for Prosthodontic Care

The number of studies demonstrating the toxicity of acrylic resins has been increasing [133–145]. The literature has shown mounting evidence of the health threat of these prosthetic materials as environmental, biological and chemical hazards. An alarming incidence of occupational health risks to dental clinical and laboratory health personnel has surfaced in the literature [134, 135, 145]. A published case report [133] of respiratory pathology in a dental student, resulting from inhalation of acrylic resin particulate matter, has caused concern about the handling of these contaminated materials within the clinical as well as the laboratory environment. Two case reports of dental technicians with generalized peripheral neuropathy from inhalation of volatilized acrylic resin liquid monomer in a laboratory setting have also been reported [131, 145]. These incidents demonstrate the necessity that dental health care planners insist on the proper use of these materials, with strict adherence to environmental hazards control through negative-pressure vacuum systems and proper ventilation.

Planners must incorporate advanced environmental control systems to protect clinicians and laboratory personnel. This issue is of particular importance to developing countries because of the high utilization rate of acrylic resin materials in low-level prosthodontic treatment procedures. A high utilization rate of acrylic resin, combined with a lack of occupational laboratory environmental standards, would render health care providers and support personnel particularly vulnerable to the occupational hazards cited above.

Edentulous Maxillae and Partially Dentate Mandible Combination

The SDA concept should be evaluated very carefully in the patient with an edentulous maxilla opposing a partial-

ly edentulous Kennedy class I mandible with few posterior natural teeth remaining. The unrestored mandible will induce residual ridge resorption in the anterior premaxilla as a result of differential loading of the maxillary prosthesis by the remaining natural teeth. This is a relatively common side effect described as the combination syndrome (also called anterior hyperfunction syndrome). Other side effects of this imbalance of forces include hyperplasia of the posterior edentulous tuberosity, pneumatization of the bony down-growth and papillary hyperplasia [127, p. 134]. The application of the SDA concept would be contraindicated in this specific situation because of these side effects, which have been shown to occur in patients with Kennedy class I RPD restorations (called Kelly's syndrome when it occurs in conjunction with mandibular Kennedy class I RPD) [127, p. 74]. In 1972, Kelly [146] reported that these side effects could occur if patients were not properly managed with follow-up relining procedures and routine professional recall care.

Conclusion

This literature review was performed to analyze the needs of developing countries when planning future prosthodontic care. Of central importance to health care infrastructure planning is determining what a society's actual requirements are. It is necessary to first undertake some evaluation of the patients' needs and expectations and to do so on a broad basis as these elements may differ across populations depending on factors ranging from cultural to racial differences. Early stages of the planning process and resource allocation should attend to both human resource development and preventive modalities; these aspects of prosthodontic care planning can be divided into three separate time periods based on result orientation and need: (1) first 5 years, (2) 5–20 years and (3) 20 years or greater. While short-term planning can address itself to immediate suffering and preventive approaches to dental diseases, longer-term planning must examine the issues of developing skilled technical staff to deal with future needs. It should also be noted that the world population demographic is increasing in age as life expectancy increases and health care systems must be prepared for the greater dental care needs of this increasingly aged population.

Several treatment and infrastructure possibilities were also examined. While many developed nations have undertaken a system expansion technique known as den-

turism, the cited literature identified several negative impacts on the quality and cost of care and would strongly caution against this approach. As well, the literature noted some strong benefit-risk developments associated with the choice between nonintervention, transitional RPD and advanced level prosthodontic treatment. Some of the risks associated with transitional RPDs include: (1) bacterial colonization of porous material adjacent to gingival tissues, (2) excessive bulk to increase strength, (3) lack of vertical support and (4) excessive suprabulge tooth coverage for stability, direct retention and reciprocation. As a result, the transitional RPD should never be utilized for more than 3 months. The choice of intervention involves important cost considerations, and factors such as the life expectancy of RPDs should be fully analyzed.

There has also been some concern raised about the safety of acrylic resin monomer and patient-contaminated particulate matter. Developing countries need to take particular care to manage the safety of laboratory and clinical personnel if technically skilled staff is to be recruited and retained. It is necessary to balance limited resources with the fundamental needs of long-term dental infrastructure building and staff safety.

As noted, the dental care requirements of a population are largely dependent on their perceived needs and personal satisfaction with care. Nevertheless, patients need to be provided with the information necessary to make informed consent, and some details of clinical analysis and possible intervention, or nonintervention, should be made available to them. For example, some countries have embraced the SDA concept, which accepts a threshold level of dentition loss. Patients and providers need to be aware that possible significant negative effects of this protocol include: (1) reduced chewing efficiency, (2) tooth positional changes such as eruption or horizontal drifting, (3) increased tooth wear and fracture, (4) loss of vertical dimension of occlusion and (5) physiologic overload on the remaining periodontium. Again, consultation on thresholds for treatment is a societal issue and should be addressed as such.

It is necessary to build infrastructure by proper planning and understanding of population needs. The issues of prosthodontic planning are issues of human resources and the examination of the outcomes of interventions which most effectively achieve the goal of a healthy citizenry. Government planning, facilitation and investment must be undertaken with care if developing nations are to look forward to a healthy future.

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