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Introduction to Minimally Invasive Dentistry: History of Minimally Invasive Dentistry and Key Concepts

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Key Topics

- Facts and figures: Demographics of dental disease
- Concept of Minimally Invasive Dentistry
- Principles of Minimally Invasive Dentistry with advantages and disadvantages
- History of Minimally Invasive Dentistry

Learning Objectives

- Be able to appreciate the facts and figures on demographics of dental disease
- Be able to appreciate the limited evidence on epidemiology of common dental diseases
- Be able to define the concept of Minimally Invasive Dentistry
- Be able to understand the principles with advantages and disadvantages
- Be able to understand the history of Minimally Invasive Dentistry and impact on clinical dentistry

Introduction

The World Health Organisation (WHO) Global Oral Health Status Report (2022) reported that oral diseases affect approximately 3.5 billion people worldwide. In this respect, it is estimated that 2 billion people present with dental caries in permanent teeth whilst 514 million children have carious lesions in primary teeth [1].

The Global Burden of Oral Conditions report revealed that untreated dental caries in permanent teeth was the most prevalent of all the 291 diseases and conditions investigated. With this respect, severe periodontitis was sixth most common and untreated dental caries in deciduous teeth was the tenth [2].

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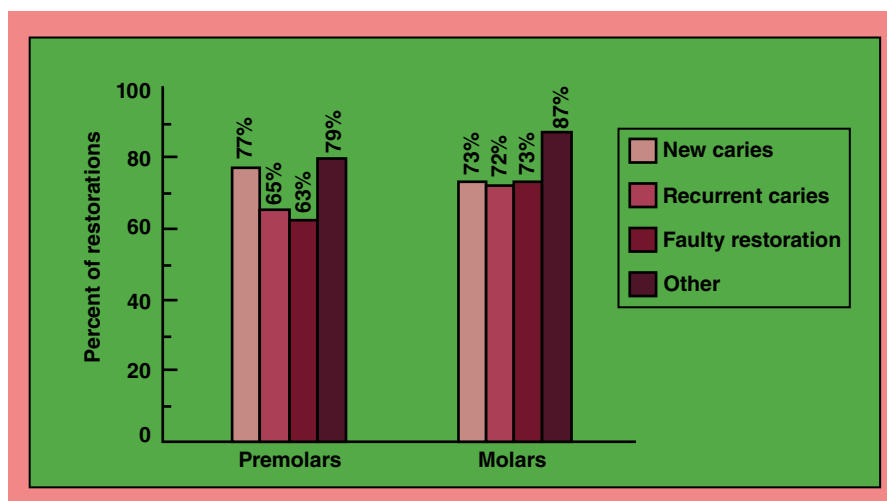


Figure 1.1 Percentage of restorations for which replacement with an increased number of surfaces according to tooth type and reason for replacement.

Following this evidence, the cost of the provision of oral care was reported to be £79 billion and that over two thirds of this cost related to the treatment of dental caries and its sequelae [3]. However, these costs could substantially be reduced if the population was educated in preventive practices and oral health care workers improved the early diagnosis of dental caries in their patients, such that enamel caries was treated with the application of fluoride and early dentinal caries with minimally invasive restorations. Elderton [4] reported a negative factor in replacing restorations which is the likelihood of increasing the size of potential new restorations. This author also emphasised the need for preventive advice and Minimally Invasive Dentistry (MID). Subsequently, Brantley et al. [5] illustrated the percentage of restorations and planned replacement with an increased number of surfaces (Figure 1.1). The reasons “new caries” and “other” (i.e., fracture, fracture risk, abutment, contact/contour problems) led to the greatest proportion of increased surfaces for premolar teeth. The reason “other” was cited most frequently by dentists who recommended replacement of restorations in molar teeth with extensive restorations. However, “recurrent caries” and “faulty restoration” led to the increase in the number of surfaces for approximately one-half of premolar and molar restorations.

The Epidemiology of Dental Caries Worldwide

Dental caries is still a major oral health problem in most countries, affecting 60–90% of schoolchildren and the vast majority of adults. Despite recent improvements in oral health of sections of the population of developed countries, overall there appears to have been some deterioration, particularly amongst under-privileged groups in developed countries

and in many developing countries [1]. It is also a most prevalent oral disease in several Asian and Latin-American countries, whilst interestingly dental caries is less common and less severe in most African countries. Frencken et al. [6], reported that untreated cavitated dentine carious lesions are the only single most common disease that affects humans worldwide.

There is evidence that the severity of cavitated dentine carious lesions amongst 5- and 12-year-old children declined over the last decades. However, the percentage of observed dental caries within these age groups is still high, with a low prevalence among 12-year-olds and among 35- to 44-year-olds in high-income countries [6].

However, the data on which the above trends have been reported must be treated with caution. International comparisons may be very unreliable due to a wide range of factors including, the threshold level for a diagnosis of caries, sampling techniques and the fact that some of the studies took place more than 15 years ago [3].

In the UK, since 1968 for adults and 1973 for children, national epidemiological surveys of oral health have taken place [7]. A remarkable improvement has been reported as far as the prevalence of dental caries in children and adults is concerned. In 1968, 37% of adults were edentulous and by 2009 this had fallen to 6% [8]. By 2013 the percentage of 12-year-old children with no obvious dental caries had risen to 66% (56% in 2003) [9]. However, within these overall improvements, there are still challenges for the management of dental caries.

More people over the age of 75 years are retaining teeth [7], which have often been restored with invasive procedures such as crowns, bridges, and dental implants. Unfortunately, due to the conditions such as rheumatoid arthritis, Alzheimer, and dementia, many are unable to maintain their oral health. In addition, reduced salivary flow affects the ability to buffer acids, produced by cariogenic bacteria, and secondary and/or root caries are more likely to ensue.

In spite of the overall reduction in the prevalence of dental caries in children, there has been a polarisation such that there has been no improvement, over the years, in dental caries in a minority of children, who invariably come from socio-economically deprived groups with the population [9]. Interestingly, extraction of teeth of those under 16 years of age, under general anaesthetic, was previously the most frequently performed hospital operation in the UK.

In order to promote the concepts of prevention for dental caries worldwide, the Alliance for a Cavity Free Future (ACFF) has been formed. The ACFF seeks to work with dental educators, clinicians, policymakers and patients to prevent dental caries and where/when these lesions occur, the ultimate aim is to diagnose and treat this disease, before there is dentinal involvement [10].

If dental caries is present, it is essential to assess its extent in a tooth. The simple diagnosis of caries present or absent is unable to help the practice of MID. A more detailed assessment with different grades is required. This concept has been incorporated in the International Caries Detection and Assessment System (ICDAS), which grades dental caries from 0 to 6 (Figure 1.2) [11]. Diagnosis of early dentinal caries (ICDAS Grade 3) can be an indication for the caries removal and the placement of a restoration following minimally invasive cavity preparation.

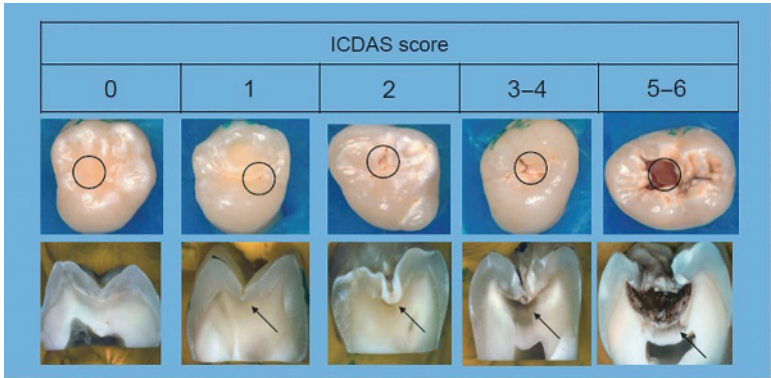


Figure 1.2 ICDAS clinical visual codes, based on evidence of the histological extent of carious lesions by staging the caries continuum. Source: Pitts and Ekstrand [11]/John Wiley & Sons, Inc.

The Epidemiology of Periodontitis Worldwide

As previously stated in 2010 the Global Burden of Disease study suggested that periodontitis was the sixth most prevalent disease on Earth. Periodontitis is a chronic, multifactorial inflammatory disease and is associated with diabetes, hypertension, and cardiovascular diseases. This disease is interestingly linked to behavioural and lifestyle factors (i.e., smoking habits, psychosocial stress, and nutrition) [12–14]. Frencken et al. [6] suggested that the prevalence and incidence of periodontitis are highly age dependent and that there is marked geographic variation. There are no meaningful gender differences and that the prevalence and incidence of periodontitis may have stagnated over the past 20 years (Figure 1.3).

In 2010, worldwide loss of productivity due to severe periodontitis was estimated to be US \$54 billion *per year*. The global prevalence of periodontal disease is expected to increase in coming years due to growth in the aging population and increased retention of natural teeth due to a significant reduction in tooth loss in the older population.

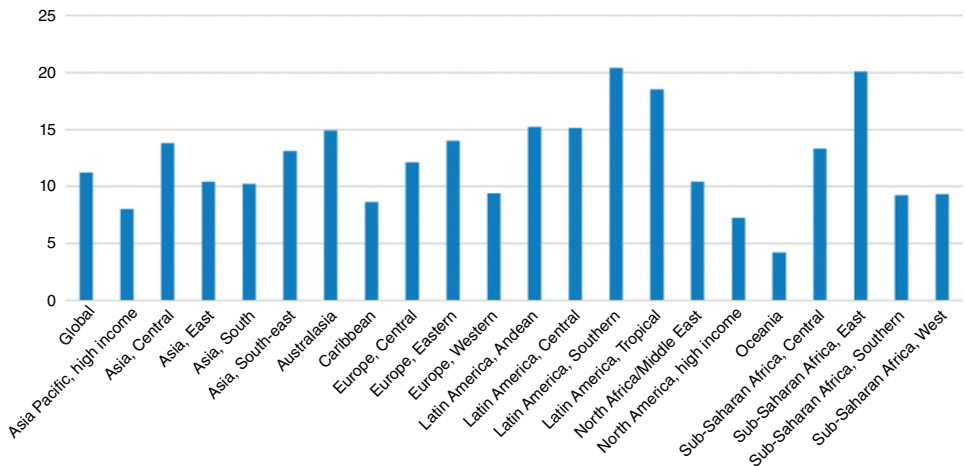


Figure 1.3 Prevalence of periodontitis globally. Source: Frencken et al. [6]/John Wiley & Sons.

However, even worse than epidemiological data for dental caries, national data for severity of periodontitis are unreliable as the thresholds for a case definition of periodontitis have varied widely from country to country [15] and also utilising the techniques for assessment [16].

Periodontal care is being provided in a variety of health systems around the world and given the global burden of disease, the active engagement of a motivated oral health professional team and patients play a key role for the management of this disease. However, as the complexity of treatment increases with disease progression, it is important to plan appropriate primary and secondary care in national health systems. Therefore, consensus on appropriate assessments and enhancement could be achieved and performed in every country for optimising the national oral healthcare strategies and services.

The Epidemiology of Tooth Wear

Tooth wear is an irreversible and cumulative condition. Tooth wear is predominantly related to multifactorial aetiology. Delayed or inadequate diagnosis with a lack of preventive intervention could lead to irreversible and advanced tissue loss. As a consequence, vitality of a tooth with function and aesthetics can be compromised. Despite the high prevalence observed in multiple countries, the information about incidence of tooth wear worldwide remains unclear.

There is some evidence with respect to tooth wear related to erosion worldwide. The global prevalence of dental erosion in children and adolescents aged between 8 and 19 years ranging from 7.2% [17] to 95.0% [18]. According to these authors, the variability in the obtained prevalence rates could be explained by using different indices to diagnose dental erosion, type of examined teeth, sample size, age, and geographic factors.

In this respect, Tooth Wear Index (TWI), which was adopted in most studies, could overestimate the prevalence, since it is not specific for detection of dental erosion [19]. In addition, geographic location seems to influence the prevalence rates observed in the literature, since cultural, ethnical, and dietary habits vary according to the regions [20].

There is a general trend to acknowledge that different aetiological factors to cause tooth wear cannot be determined and analysed separately. Therefore, considering the evaluation of exposed tooth tissue, the presence of enamel/dentine or only dentine exposed fails to explain the heterogeneity of the data presented in the literature.

The Epidemiology of Tooth Loss

The National Institutes of Health estimate that there are 158 million people without teeth worldwide and 120 million Americans are missing one or more teeth according to the Centers for Disease Control (CDC) NHANES data (Figure 1.4).

Data on tooth loss reflects not only dental disease worldwide, however this information will give an indication of patients' and dentists' attitudes, the dentist-patient relationship, the availability and accessibility of dental services, and the prevailing philosophies of dental care [21, 22].

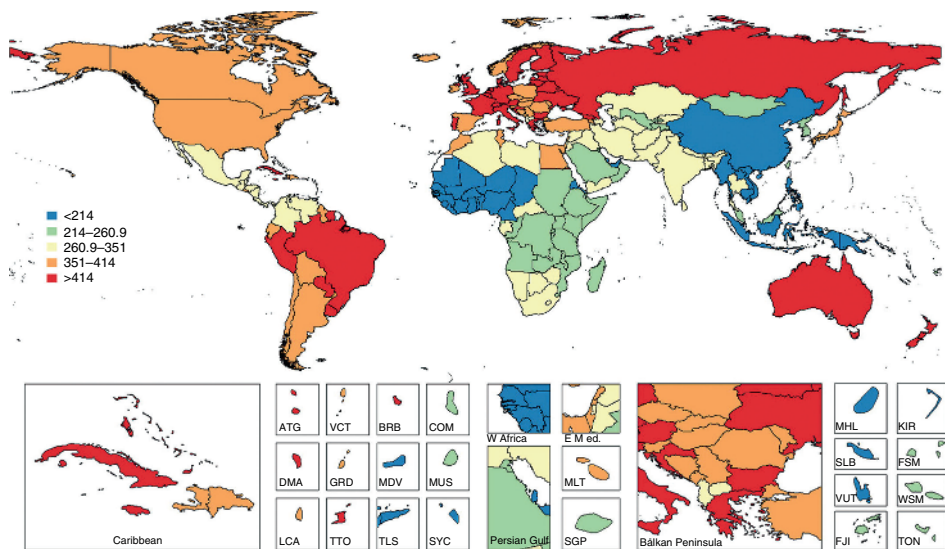


Figure 1.4 The worldwide distribution of severe tooth loss incidence *per* 100,000 persons [23].

The global age-standardised incidence rate of severe tooth loss in 2010 was 205 cases *per* 100,000 person-years (95% UI: 187, 226). There was a significant decrease of 45% from the 1990 incidence rate of 374 cases *per* 100,000 person-years (95% UI: 347, 406). Women generally showed higher age-standardised prevalence and incidence of severe tooth loss when compared to men. However, the gap between gender has reduced over time with only minor differences since 2010. In both genders, prevalence increased gradually with age, showing a steep increase around the seventh decade of life that was associated with a peak in incidence at 65 years old (Figure 1.5). These age patterns have not changed during the past two decades in spite of the gradual declines in prevalence and incidence within the same period.

Sound knowledge on current trends in tooth loss is vital for planning dental services and workforce as well as for updating the dental education worldwide. However, the epidemiology of tooth loss has not yet been fully analysed. In addition, Kudsi et al. [24] reported

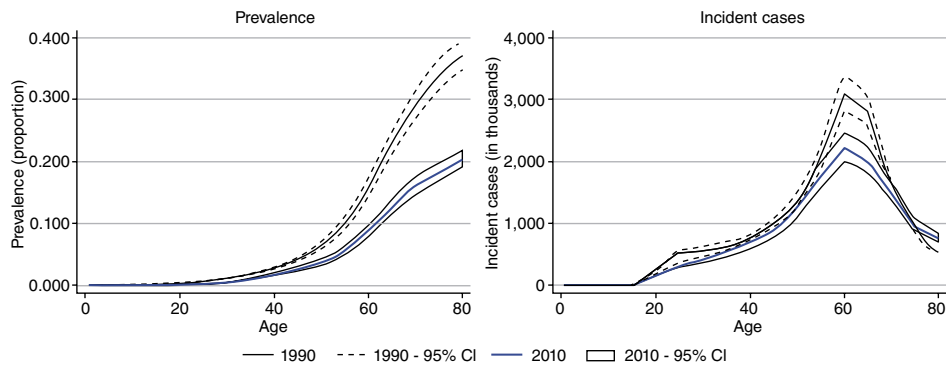


Figure 1.5 Prevalence (proportion) and number of incident cases of severe tooth loss in 1990 (light line) and 2010 (dark line) with 95% uncertainty intervals by age.

tooth loss and removable dentures could be associated with body image dissatisfaction and psychologic morbidity. Therefore, planning for patient-centred care is paramount prior to extracting any teeth and providing replacement options, especially removable dentures.

The Concept of Minimally Invasive Dentistry (MID)

The concept of MID supports a systematic understanding for the hard and soft tissues, including diagnosis, risk assessment, preventive treatment, and minimal tissue removal on dental treatment. The motivation for MID emerges from the fact that restorations are not for life. The main reasons for failure are secondary caries, tooth/restoration fracture, and decementation/debonding. To overcome these issues, there is an urgent need for establishing guidelines to maintain the oral health and retain the healthy natural hard and soft tissues as long as possible.

Therefore, the key concepts are:

- Correct early detection of disease
- Thorough risk assessment
- Patient education on awareness and knowledge of oral health
- Targeted preventive treatment to stop the disease
- Restoration of the lesion, if required, with as little removal of healthy tissue as possible
- The use of durable material if required
- The prevention of disease recurrence

Principles of Minimally Invasive Dentistry (MID) with Advantages and Disadvantages

To date, there is a lack of an evidence-based approach for MID. Therefore, there are advantages and disadvantages with this concept according to the literature to date (Table 1.1).

Table 1.1 The advantages and disadvantages of MI concept in clinical dentistry.

Advantages	Disadvantages
Patient's well-being	Lack of concrete evidence with multi-centred randomised clinical trials
Conservation of the hard and soft tissues	Limited indication in some cases
Cost effectiveness—long-term benefit	If not implied adequately, MID can be more damaging
Reduced need for the use of local anaesthetics	Remineralisation is only possible with non cavitated lesions
Hard and soft tissue engineering	Some minimal invasive methods have less survival rates
Routine reassessments and maintenance	Patient compliance orientated strategy

The History of Minimally Invasive Dentistry (MID)

MID has developed over the past 20 utilising the preventive measures to preserve natural tooth structures. The science for MID is advancing to enable individuals to retain more teeth for longer.

Interestingly, despite being blamed for the “extension for prevention” concept, Black published a series of papers and texts on dental materials and preparation and restoration techniques between 1869 and 1915 on minimal intervention strategies. Black was the first dentist to propose treating dental caries using minimal intervention based on the knowledge and materials available at that time.

The basic philosophy of MID recognises the fact that all restorations have a finite life and that large restorations (either composite or amalgam) have a shorter longevity than smaller ones. Black made a statement in 1891: “...And if the filling should serve for five, ten, or fifteen years, valuable teeth will have been saved to the patient that much longer by filling and afterward crowning, than by present crowning....” It was clear that Black encouraged the clinicians to choose the least invasive option since the more invasive option would usually be available for a later date.

MID became a popular approach following the enhancement of bonding principles within the hard tooth structure. In 1955, Buonocore described a technique for etching enamel surfaces to make them retentive for a restoration. In 1962, Bowen submitted a patent, entitled a “Dental filling material comprising vinyl silane treated fused silica and a binder consisting of BIS phenol and glycidyl acrylic,” that enabled the restoration of a tooth with a tooth-coloured plastic better known today as Bis-GMA. These two developments led to the MID.

Subsequently, the MI philosophy was introduced by the application of silver fluoride diamine to dental caries in the early 1970s [25]. Newly developed, this cariostatic agent is the original preparation diammine silver fluoride ($\text{Ag}(\text{NH}_3)_2\text{F}$) (generally called: silver ammonia fluoride). For the purpose of caries prevention and the desensitisation of hypersensitive dentine, either fluoride or silver nitrate has been used.

Summary

A new paradigm using MI techniques for a more comprehensive and holistic approach to manage dental diseases can provide sustainable and focusing less on national/international resources by actively contributing to the improvement of patients’ well-being and oral health for general health. In addition, MI strategies aim to reduce the replacement of dental restorations since every year, despite the effectiveness of preventive dentistry and dental health care, 75% of restorations fail and require replacement [26], which has an enormous socio-economic impact.

Overall, cumulative effects of dental diseases on oral health and also for general health strongly suggest prevention and patient-centred approaches using futuristic sustainable materials.

Further Reading

General

Adult Health Survey UK is an authoritative and free website based in the UK, written and reviewed by experts on dental public health, clinical academics, and other health professionals: <https://digital.nhs.uk/data-and-information/publications/statistical/adult-dental-health-survey/adult-dental-health-survey-2009-first-release>.

MI compendium (online resource).

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