Introducing the Concept of Pragmatic Esthetics, with Special Reference to the Treatment of Tooth Wear

INTRODUCTION

The impact of the so-called "cosmetic" dentistry, if assessed by the number of dental makeovers in television programs or in celebrity magazines, has increased substantially in recent years. This is likely to have increased the public's awareness of their dental appearance,[1] and in turn, may have increased the volume of porcelain laminate veneers that have been placed, although quantification of this is difficult. What is quantifiable, however, is that tooth wear (TW) alternatively known as tooth surface loss (TSL) is increasing in incidence,[2] especially in younger people, and that the issues around treatment of this are, therefore, becoming increasingly relevant.

In the past, treatment of TW was often by means of crowning affected teeth (Figures 1A–C), or by a "full oral rehabilitation." This involved the crowning of many innocent or bystanding teeth, allegedly with the aim of protecting their surfaces from further TW. The irony, of course, was that the supposed "ideal" treatment plans resulted in either more massive destruction of the affected teeth than the causative factors themselves had produced, or even more curiously, caused significant destruction of other minimally affected teeth in the same arch, or the opposing arch. This could be considered by many people to be a strange way to treat teeth, which were already compromised by wear. More seriously affected cases were (and still are) offered overdentures, or

FIGURE 1. A and B, 1995: Pre-op view of a patient suffering from erosive TSL. C, Three years post-treatment, following provision of five dentine-bonded crowns.

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even, extractions as a preliminary to implant therapy, or just standard dentures. Many of these destructive preparations were done in order for the resultant restorations to conform to a rigid, almost fundamentalist, occlusal philosophy for example, "group function occlusion,"[3] "canine-guided occlusion,"[4] or "mutually protected occlusion."[5] Such occlusal philosophies were, and sometimes still are, espoused by their devotees as having scientific proof, when in fact they have little, if any, high-quality supportive evidence proving that they deliver long-term benefits for teeth treated according to the tenets of that particular belief system.

Occlusal beliefs are fine provided that the structure or the pulps of the treated teeth are not grossly damaged in the unquestioning pursuit of these dogmatic "occlusal objectives." In the defense of these somewhat dated ideas, in the 1950s and early part of the 1960s, when these occlusal philosophies were being popularized, many of those full-mouth rehabilitation treatments were being undertaken at a time when the dentitions had already been ravaged by real disease, such as caries, which was often treated by large fillings and/or extractions. Furthermore, in the 1950s and 1960s, those doing big rehabilitations were mainly using materials like gold and acrylic facings, which required relatively little of the remaining sound tooth structure of the remaining teeth to be removed. These preparations probably did less structural or pulpal damage to the teeth than that now being caused by extensive preparations for porcelain fused to metal or all-ceramic restorations of various types.

Fundamentalism has now spread into the field of "cosmetic dentistry." It seems that much destruction of innocent sound tooth structure may now be undertaken, sadly, to produce the supposedly "ideal esthetic appearance" along with "proper" occlusion. This supposed, currently fashionable, ideal appearance often resembles that of an upper denture, with the teeth being even and very white, with the smile being wide, with the net effect of making the mouth look more prominent than many dentists feel is appropriate or natural.

EPIDEMIOLOGY OF TOOTH SURFACE LOSS

The cause of TSL or TW (hitherto in this paper being termed TSL) has been described as multifactorial, being mainly due to erosion, attrition, abrasion, and, possibly, abfraction. The volume of TSL becomes increasingly significant when two or more factors are working concurrently. In many cases, just one cause of TSL is predominant. For example, bulimia nervosa produces erosion on the palatal aspects of the maxillary anterior teeth. In this condition, the lower teeth are protected, to an extent, at least by the position of the tongue when vomiting occurs carrying the stomach acid (pH 1) onto and past the palatal aspects of the upper teeth, but often sparing the lower incisors to a greater extent. In practical preventive terms, the palatal aspects of these teeth can be protected easily and effectively with direct composite, leaving the lower teeth without intervention, unless absolutely necessary.

TSL may be considered pathological when extensive areas of dentine are exposed, and may be measured by indices such as those proposed by Smith and Knight in 1984,[6] or more recently, by Bartlett.[7] The incidence of TSL has recently been examined in the 2009 UK Adult Dental Health Report.[2] The results indicated that

1 77% of dentate adults showed some TSL in their anterior teeth.
2 15% showed moderate wear, 2% had severe wear.
3 Men had higher incidence of TSL.
4 Moderate TSL increased from 11% in 1998 to 15% in 2009.

Severe TSL remained rare but had increased since the last survey. However, no comment was made, for instance, on the effect this had on tooth color, particularly with respect to the exposure of the darker dentine, or on support for the soft tissues, or on visibility of the eroded or worn teeth.

The prevalence of TSL in adults has recently been the subject of a systematic review by Van't Spijker *et al*.[8] Thirteen papers survived the inclusion procedure. The results indicated that the percentage of adults with

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severe TSL increased from 3% at age 20 years to 17% at age 70 years, and it appeared that increasing levels of TSL were significantly associated with age. Furthermore, in a paper describing a new index of TW,[9] 1,010 students in London, aged 18 to 30 years, were examined for TSL. The results indicated that

1 Enamel wear was common to all subjects.
2 6.1% had more than one third of their tooth surfaces affected.
3 Dentine was exposed on 5.3% of all surfaces.
4 76.9% had one or more surfaces with dentine exposed.
5 Males had significantly more wear than females.

In contrast, results of a systematic review in adolescents,[10] in which 29 papers were reviewed (including 45,186 subjects) indicated that TSL involving dentine in primary teeth ranged from 0% to 80%, but that the increase in TSL with age in adolescents was not substantiated.

Smith and Robb[11] published the results, in 1996, of their examination of 1,007 patients: of these, only 9 had no TSL. Other findings were of considerable concern such as patients under 26 had the worst TSL. This level of wear was not matched in the 26 to 35, 35 to 45, or 45 to 55-year age groups, and equivalent wear was only noted in the 55- to 65-year group. The significance of that very detailed analysis was that something different (probably erosion) was happening in the under-26 group. This has enormous implications for the teeth involved as well as for resource allocation in respect of helping with the problems associated with this cohort as they get older. The detail of the results indicated that

1 There was extensive tooth TSL in 10% of those examined.
2 Males had more TSL than females.
3 5.1% of the surfaces examined were extensively worn.
4 9% of the surfaces in the oldest age group were extensively worn.
5 22% had more than 10% of tooth surfaces worn to an unacceptable degree.
6 Incisal edge TSL of upper and lower teeth was most severe and increased with age.
7 Cervical anterior tooth TSL also increased with age.

The results of these studies suggest that TSL is a substantial problem, and there is a suggestion that its incidence is increasing. Esthetic problems, which TSL produces, may involve the color, shape, and visibility of the teeth, at rest and smiling. In this respect, lack of tooth showing during normal speech and smiling can be a significant esthetic issue for some people as it may be considered to produce a prematurely ageing effect.

ACHIEVING SPACE FOR THE RESTORATION OF WORN ANTERIOR TEETH

A concept for achieving the necessary space for restoration of anterior teeth affected by TSL was put forward by Dahl in the 1970s,[12] although the original work examining the effect of placing a supra-occluding restoration on a posterior tooth was originally described by Anderson in 1962.[13] Dahl used a removable appliance limited to the palatal aspects of maxillary anterior teeth affected by TSL (the so-called Dahl Appliance), causing disclusion of the posterior teeth. Later versions were cemented cobalt chromium appliances. Dahl[12,14] reported that the posterior teeth later subsequently regained occlusal contacts. Based upon lateral skull radiographs of unknown reproducibility and a small number of individuals, this effect was attributed to be a combination of intrusion of the anterior teeth and eruption of the posterior teeth. However, mandibular condylar repositioning to a more superior and retruded position could also be considered to account for some of the changes reported.

Dahl used the space created to restore teeth affected by TSL with conventional extra-coronal restorations—a two-step procedure, with individuals in both Anderson and Dahl's studies appearing to tolerate the localized changes well. Since the publication of Dahl's studies, other workers have taken the concept further in the management of localized TSL,[15] utilizing the

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cementation of cobalt chromium appliances, as well as adhesive techniques in combination with metal and composite.

BONDING TO DENTINE

Although much effort has concentrated on improving bonding to dentine, the bond strengths to enamel remain unquestioned since it has long been known that bonding to enamel, using 35% phosphoric acid to create a retentive enamel surface, is predictable and reliable.[16] In TSL cases, there is generally a peripheral amount of enamel, especially near the gingival crevice where crevicular fluid probably neutralizes acid attack, thereby preserving the enamel in that area. Preservation of this enamel is enormously important, and bonding composite to the residual peripheral enamel that remains is an important part of the technique. This residual peripheral enamel may be termed "*the enamel ring of confidence*." Furthermore, bonding composite to the enamel on the lingual aspects of worn lower incisors (where there is always space and good enamel for reliable bonding) remains a very important aspect of managing worn lower teeth.

Until recently, however, the achievement of a reliable bond to dentine has been elusive, due in part, to its organic component, which is 20%, and its water content (10%) and the fact that early dentine-bonding agents were very technique sensitive. Much research has concentrated on this.

Currently, bonding agents may be classified into etch and rinse (alternatively termed etch and bond, or total etch) or self-etch, with the latter being subclassified into strong etching potential and mild self-etching potential.[17] In the self-etch materials, the bonding agent is of sufficiently low pH to etch the dentine surface and initiate bonding, but most recently, doubt has been raised over the effectiveness of the bond to enamel of the self-etch systems. The self-etch systems are attractive because of their ease of use, but their clinical effectiveness, as measured by retention of restorations in nonretentive cavities such as Class V, has been considered to be less than ideal in a systematic review published in 2005[18] and in other publications such as that by van Dijken in 2007.[19] It may therefore be considered that the etch-and-rinse systems optimize bonding and that these should be used in cases where retention of the restoration is principally achieved by the bond to dentine, such as in Class V cavities and in the treatment of cases of severe TW where little enamel remains for bonding. However, there is recent evidence, from Akimoto *et al*.[20] in a 10-year assessment of a self-etch adhesive, and Peumanns and colleagues[21] in an 8-year evaluation of a self-etch adhesive, that the performance of self-etch adhesives *may* be improving. Should a number of additional papers also demonstrate their clinical effectiveness, it may then be considered that some self-etch materials perform sufficiently well to be utilized in the clinical situations where the restoration is retained wholly by the action of the bonding agent.

Most recently, the concept of selective enamel etching has been put forward.[21] In this, the enamel cavity margins are etched with 35% phosphoric acid and the dentine surface is not etched. This technique has been demonstrated to produce margins to enamel, which are less prone to staining and has been considered to give protection to the dentine bond by the creation of a protective enamel/composite interface.[21] However, it may be postulated that self-etch systems may be used satisfactorily in clinical situations where there is adequate resistance and retention form. That is by no means without controversy. The current one-bottle systems do not enjoy the clinical evidence that the more established three-bottle systems do or some of the evidence for two-bottle systems with prior enamel etching.[22]

OPTIMAL TOOTH FORM

A number of publications have demonstrated that good dental appearance is of importance to patients. For example, the work by Davis and colleagues, in which patients who received porcelain laminate veneers were assessed psychologically, with the results indicating that esthetic dental treatment had a positive effect on

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patients' self-esteem.[23,24] Earlier, in 1986, Jenny and Proshek[25] asked five groups of subjects to rate the importance of dental appearance for entry into 88 occupations, with the results indicating that dental appearance that deviates from acceptable norms might reduce one's life chances, and that dentofacial disorders might hinder career aspirations and career opportunities.

However, it has been shown that dentists' and patients' views on dental esthetics may not always coincide.[26] It has been demonstrated, in a study on 3,526 patients, that patients were not always aware of the improvements in dental esthetics which the clinician can offer, with this discrepancy being shown to increase with increasing patients' age.[27] More recently, Samorodnitzky-Naveh and colleagues[28] also investigated the satisfaction of 407 adult patients (who were attending an Israeli military dental clinic) with the appearance of their dentition. Overall, 37% were dissatisfied with their dental appearance, with tooth color being the primary reason for dissatisfaction followed by poor tooth alignment.

The earliest work on the esthetic and anatomical basis of tooth form was published by Leon Williams in 1911, this being a transcript of a lecture given in Denver, CO, USA in 1910.[29] He stated that his work was a work in progress. It could be considered that, today, this is still the case! The greatest impact, in recent times, on developing a basis for ideal tooth form and the size of anterior teeth in relation to the adjacent tooth, may be considered to be Levin's 1978 paper on the Golden Proportion, in which he proposed that the ratio of the central incisor tooth to the lateral incisor tooth to the canine tooth is 1.6/1/0.6 when viewed from in front of the patient.[30] Recently, the Golden Proportion concept has been questioned, with Preston measuring a sample of 58 images of maxillary and mandibular teeth of 58 second-year dental students and 52 actual casts.[31] The Golden Proportion was *not* found to be correlated with the relationship between the maxillary central incisor and maxillary lateral incisor, nor was the Golden Proportion found to exist between any perceived maxillary lateral incisor and canine widths. Preston pointed out that the problem with the Golden Proportion as applied to teeth is that it measures the "apparent," rather than the "actual" width of the teeth.

The Golden Proportion was investigated by Bukhary and colleagues[32] using digital alteration of a female smile in order to change the proportion of the maxillary lateral incisor teeth in proportion to the central incisors, with the images being judged by 87 patients and 30 dentists. The results indicated that there was no evidence to suggest that the Golden Proportion should be considered the ideal esthetic standard when creating space for the replacement of missing maxillary lateral incisors.

Recently, Ward[33] has compared the recurring esthetic dental (RED) proportion to other mathematical and naturally occurring proportions by using the views of 301 dentists who were attending continuing dental education courses throughout the United States. The dentists indicated no significant difference in preference between the Golden Proportion and the Golden Mean and showed that dentists preferred the smiles of the naturally occurring maxillary tooth proportions and the 70% RED proportion over the Golden Proportion. In addition, the majority of dentists reported that overall balance was a primary factor. In a study of tooth width, Goncalves and colleagues[34] made casts of 69 dentate undergraduate students in Brazil, considered to be a heterogeneous population because of its ethnic mix. They measured the individual widths of maxillary anterior teeth using digital callipers, with the results indicating that there was a significant difference between analogous teeth from both sides of the dental arch with the exception of the central incisors.

Gomes and colleagues,[35] using standardized digital images of 81 dentate Brazilian subjects, measured the combined mesiodistal width of the six maxillary anterior teeth and correlated this with the intercanthal width, the interpupillary distance, and other facial measurements (interalar width, intercommissural width), with the results indicating a significant correlation between all the facial elements measured and the combined mesiodistal width of the six anterior teeth, when observed from the front.

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Arguably, the greatest volume of recent work relating to the dimensions of teeth has been carried out by Chu and colleagues in a series of papers. He has suggested that practitioners have become hidebound by mathematical principles and instead proposed the use of an innovative esthetic-measuring gauge to enable the quantification of tooth size discrepancies and enable the clinician to perform esthetic dentistry predictably.[36] He has also introduced this approach to crown lengthening.[37] Chu also examined 54 casts from patients, measuring the widths of anterior teeth, finding that the central incisors, lateral incisors, and canines varied in width from 7 mm to 10 mm, 5.5 mm to 8 mm, and 6.5 mm to 9 mm, respectively, and that only 36% of the total population exhibited the mean tooth width of 8.5 mm for central incisor teeth. However, 82% of the patients fell within ±0.5 mm of the mean values.[36] For male patients, maxillary anterior teeth ranged from 0.5 mm to 1 mm wider than for female patients. With regard to the mandibular dentition, Chu and Okobo examined 70 stone casts from 36 male and 34 female patients in a private practice population, finding that mandibular anterior teeth are more consistent in size and variability than maxillary anterior teeth and only the mandibular canine teeth exhibiting a gender difference.[38] These workers added that "while anatomic values of tooth size are well established in the literature, there is a misconception that these absolute numbers are applicable to the majority of patients." Finally, Chu and colleagues examined the gingival zenith position at 240 sites in 20 adult patients of mean age 28 years who exhibited no periodontal disease. The results indicated that the gingival zenith position of the lateral incisors relative to the adjacent central incisor and canine teeth was more coronal by *circa* 1 mm.[39]

In summary, it could therefore be considered that when restoring broken down or worn teeth, creation of maxillary central incisors of the same width is an important (indeed, central!) consideration. It also seems that the appearance will be enhanced if there is symmetry around the midline[26] and if the gingival zenith position of the lateral incisors relative to the adjacent central incisor and canine teeth is more coronal by *about* 1 mm.[39] Furthermore, examination of patients' preferences has illustrated that horizontal symmetry is preferred by them, whereas dentists' preference is for radiating symmetry.[26]

THE CONCEPT OF PRAGMATIC ESTHETICS

Pragmatic is defined, in the *Oxford English Dictionary*,[40] as (*adjective*): "dealing with things sensibly and realistically in a way that is based on practical rather than theoretical considerations." Its origin is via Latin from Greek *pragmatikos* "relating to fact," but it may be considered that the synonyms presented in a thesaurus[41] also appropriately represent the meaning of the adjective as used in this paper, namely *sensible*, *efficient*, *down to earth*, *commonsensical*, and *realistic*.

Factors other than those mentioned in the section above may influence dental esthetics, such as tooth color, tooth position, gingival esthetics, tooth visibility, and tooth position.[42] The literature is replete with examples of these, but in some cases, improved esthetics is achieved at the cost of an enormous loss of tooth substance.[43] Furthermore, in many case reports, there would appear to be a dangerous disregard for the long-term pulpal health of the teeth, which are prepared, given the well-known potential for pulp death following tooth preparation for crowns.[44] In one such case,[43] a 20-year-old patient whose spaced anterior teeth were affected by amelogenesis imperfecta received adhesive resin composite restorations which effected an improvement in esthetics. These were treated as provisionals, since the patient later received 28 crowns, with a "superb aesthetic result."[43] However, the patient's appearance had already been greatly enhanced by the composite restorations. These composite restorations may not have achieved quite the esthetics of the ceramic crowns, as viewed by some dentists, but likewise, the composite approach did not result in the loss of any sound load-bearing tooth structure or run the risk of potential pulp death, which the ceramic crowns necessarily involved. Herein lies the argument for the concept of *Pragmatic Esthetics*—in which the esthetics of the patient's anterior dentition has been improved from the original appearance, but may not be perceived as "dental perfection." In other words, the appearance of the teeth has been made as good as it can

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be without causing any significant damage to tooth structure or a need for destructive periodontal surgery. Anecdotally, the authors report that, on examining their new dental appearance, patients may frequently remark—"Wow—it is a big improvement" (even if it is not perfect as viewed by some "fundamentalist" cosmetic dentists). Such achievement of patient satisfaction may be considered to represent successful treatment, even if the esthetics may not conform to perfection.

The concept of *Pragmatic Esthetics* will now be illustrated by a series of case reports, in which the preoperative esthetics of the anterior dentition ranged from poor to less than ideal. In all cases, however, the treatment objective was to protect the teeth from further wear. The improvement in esthetics could therefore be considered to be a bonus. In addition to the minimally invasive nature of the techniques that will be described, in the challenging economic times, which prevail at the time of writing, the use of these direct-placement restorative techniques, which employ considerable skill but minimal laboratory costs, could be seen by patients as economically very attractive, in comparison with those in which indirect techniques are utilized. The savings to the patient are mainly in relation to maintaining their valuable sound, load-bearing tooth substance. Patients who understand the concept of "self-preservation" with some dental improvement are usually happy to pay a fair fee, and often a premium, to avoid the "self-destruction" involved in multiple crowns for wear. Indeed, it could be suggested that patients should pay more for preservation, rather than destruction, of their sound tooth substance!

CASE REPORTS

Case 1

The patient, a 45-year-old male, was referred, complaining of sensitivity and less-than-ideal appearance. He admitted to consumption of 2 L of carbonated drinks daily. His history also included previous acid regurgitation, for which he was taking medication. Clinical examination (Figures 2A and B) showed severe erosive TW, affecting, principally, the maxillary anterior teeth, with the pulp being visible through a thin film of dentine in UL3. Study casts were made, principally for the instruction of the patient. He was advised that treatment, to cover the exposed dentine surfaces, was essential and that this should be carried out at the earliest possible convenient appointment so that the pulp at UL3 did not become exposed.

The patient was also advised:

1 That his anterior teeth would receive adhesive resin composite restorations to cover the exposed dentine and that that was the principal reason for treatment.
2 That an esthetic improvement would be effected if possible.
3 That his posterior teeth would be discluded for a period of 3 to 6 months, and that he would therefore have to cut his food into small pieces.
4 That the change in shape of the maxillary anterior teeth might cause lisping.
5 That the anterior teeth (which are being subjected to axial orthodontic tooth movement) may be painful for a number of days.
6 That he would find difficulty in mastication for a period of approximately 72 hours, but that he would then become accustomed to his new "bite."
7 That the reliability of the restorations would be good, but that there was a small potential for restorations to debond, since bonding, albeit better than 15 years ago, was still not as good as clinicians might desire.
8 That the margins of the resin composite restorations might require occasional refinishing and polishing.
9 That the procedure would be carried out without the need for local anesthesia as there would be no, or minimal, need for tooth reduction.

Following discussion of these points, consent was given and the treatment commenced. The teeth were cleaned using pumice and water and the bonding agent Scotchbond 1 (3M ESPE, St. Paul, MN, USA) was used, following etching with 35% phosphoric acid. The restorations were formed, freehand, in Filtek Supreme XT (3M ESPE: A2 body and enamel), with metal strips

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FIGURE 2. Case 1. A, Severe erosive tooth wear, with near pulp exposure at UL3. Interproximal caries were initially treated using a resin-modified glass ionomer cement. B, Chipped incisal enamel margins indicative of erosive tooth wear. C, Resin composite build-ups UL4 to UR4. Initial occlusal assessment indicates relatively even occlusal contacts. D, Improved appearance of central incisor teeth. The posterior teeth are slightly discluded. E and F, Situation at 4 years. The anterior restorations have maintained their lustre.

being placed between the teeth during these procedures. Retraction of the lips and cheeks was achieved using Optragate small (Ivoclar Vivadent, Schaan, Leichtenstein). Initial occlusal adjustment, finishing, and polishing of the restorations was carried out at the first treatment visit (Figure 2C), although the patient experienced difficulty in achieving a reproducible intercuspal position. The patient was advised that final occlusal adjustment and polishing of the restorations would be carried out on the second visit a week later. On that occasion, the restorations were checked and adjusted in intercuspal position and

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FIGURE 3. Case 2. A and B, Patient presented with "spade"-shaped teeth, erosive tooth wear affecting the palatal and incisal aspects of his maxillary incisor teeth, and a complete overbite. C, Immediate post-op. D, Condition at 5 years.

in protrusive and lateral excursions. The patient expressed pleasure at the appearance of his teeth and stated that the sensitivity had disappeared. Subsequent treatment involved the re-root filling of UR6 followed by placement of full-thickness zirconia (Lava, 3M ESPE, Seefeld, Germany) crowns at UL5 and UR6. Flowable composite restorations were used to restore a number of cervical defects. The patient attended for annual review. Figures 2E and F present his condition after 4 years. UL3 remained vital to testing.

Case 2

The patient, a 22-year-old male, was referred, complaining of less-than-ideal appearance and slight sensitivity. He suffered from gastric regurgitation and also drank half a liter of carbonated beverages daily. Clinical examination (Figures 3A and B) showed severe erosive TW, affecting, principally, the palatal aspects of the maxillary anterior teeth, which appeared "spade" shaped, and a complete overbite, with the mandibular incisors traumatizing the mucosa palatal to the maxillary incisors. The patient stated that he felt that his poor dental appearance was hindering his career. Treatment was offered to restore the teeth using Scotchbond 1 (3M ESPE) and resin composite build-ups to cover the exposed dentine areas and to close the diastemata. The various advantages and disadvantages of the procedure were presented to the patient as per Case 1. Consent was given and the treatment carried out (Figure 3C). On a second visit, the restorations were checked and adjusted in intercuspal position and in protrusive and lateral excursions. The patient considered that his dental appearance was greatly improved. He was offered crown-lengthening surgery, since in the completed build-ups, the appearance of his maxillary central incisor teeth was rather square. He declined this, considering that his teeth already looked substantially improved over their original appearance. At 5 years (Figure 3D), the patient reported that the treatment had improved his confidence substantially, that as a result, his career had "taken off" and that he was about to get married.

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Case 3

The patient, a 64-year-old male, attended complaining of dark, chipped teeth, which were "wearing away" (Figure 4A). He was a fitness fanatic who played squash daily and drank only "healthy fruit juices like fresh orange." A full history and examination was undertaken, with the patient expressing a wish to have modest improvement to the appearance of his teeth, at the same time as having his teeth protected from further wear without any "self-destruction." Clinical examination showed a Class 2 division 2 malocclusion and more marked wear on one side, implying a parafunctional habit. A post crown at UR5 had been lost, and there were large areas of dentine exposed on the maxillary and mandibular incisor teeth (Figure 4B). The treatment plan, which was suggested, involved nightguard vital bleaching, followed by the rebuilding of the anterior teeth using resin composite restorations. One week after the cessation of bleaching with standard nightguard bleaching using 10% carbamide peroxide (Figure 4C), and prior to etching, metal strips were placed interproximally in order to prevent the teeth being treated being bonded to each other (Figure 4D). All the upper and lower anterior teeth were built up at the same visit. Following bonding with a three-bottle bonding etch-and-rinse dentine-bonding system, the palatal and incisal aspects of the upper teeth were built up first, freehand, without a matrix (Figure 4E). The labial aspect was then done, compressing the material against the lengthened teeth. Using the metal strips to stop acid etching of the interproximal areas of the slightly crowded Class 2 division 2 incisor teeth speeds up the finishing time while still leaving tight but cleansable contact zones. Abrasive discs (Soflex, 3M ESPE) were used to shape the restorations (Figure 4F), with final polishing using diamond polishing paste. The mandibular incisors were built up in bulk by "shrink-fitting," i.e., by pressing the hybrid composite (Charisma, Heraeus Kulzer, Hanau, Germany) from the lingual enamel across the worn dentine and onto the labial aspects. The teeth were shaped with tungsten carbide burs prior to finishing. Mild irregularities were created at the patient's request (Figures 4G and H).

Case 4

This 36-year-old female was referred by her general dental practitioner because of the poor esthetics of her upper anterior teeth. The central incisors had started to chip and had been smoothed off, this, unfortunately, further reducing the amount of tooth structure. The central incisors were 8.5 mm in length. She had been treatment planned for four all-ceramic restorations but her dentist considered that because of the limited tooth tissue, the patient required specialist care.

The pretreatment photographs showed erosive TSL affecting the palatal surface of the six anterior teeth and poor esthetics (Figure 5A). The patient stated that she had suffered from bulimia nervosa in her early 20s.

A diagnostic wax-up was constructed (Figure 5B), the aim being to conserve tooth tissue and increase the length of UR1 and UL1 but maintain the slight imbrication of the lateral incisors. The "Dahl approach" was to be used. The diagnostic wax-up was discussed with the patient, and a plan of direct composite restorations was agreed upon.

The existing restorations in UR1 and UL1 were removed, and composite (3M Filtek Supreme XTE Shade B1) was added on the palatal surfaces of the six anterior teeth and to the incisal and buccal surfaces of UR1 and UL, with composite also being added to the mesial and incisal surfaces of these (Figures 5D–F). At the time the composite was placed, the posterior teeth were discluded. The patient was monitored for 6 months, after which time the posterior occlusion had reestablished, with multiple contacts.

DISCUSSION

Changes in tooth length occur as a result of TSL,[45] with the interproximal contact becoming shorter (Figure 6). Tooth width has been demonstrated, in a study of 146 extracted maxillary anterior teeth, to generally remain constant.[45] It therefore goes without saying that there is an esthetic challenge in restoring worn teeth. Although the treatment prescribed in the cases described was

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FIGURE 4. Case 3. A and B, Initial presentation of case. C, Appearance following bleaching. D, Metal strips placed interproximally. E, Incisal aspect of the affected teeth built-up first. F, Shaping of the final restorations. G and H, Completed treatment of case.

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FIGURE 5. Case 4. A and B, Initial presentation of case. C, Diagnostic wax-up. D, E, and F, Completion of case.

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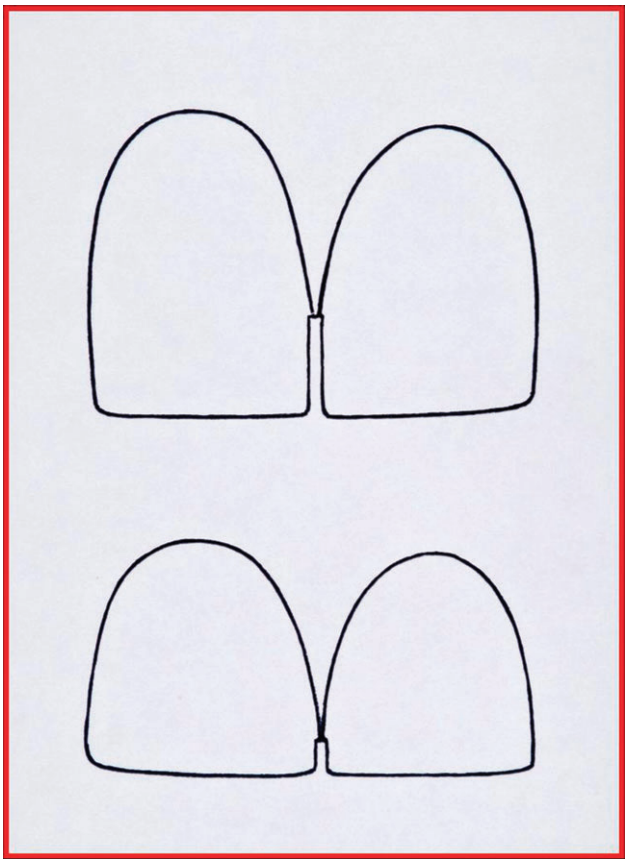

FIGURE 6. Interproximal contacts become shorter as a result of TSL.

primarily for the protection of the patients' teeth from further TSL, they varied in the potential for esthetic improvement because of the positioning, form, or color of the teeth preoperatively. The teeth in Case 2 were square on completion of treatment, and the patient refused crown lengthening, but the esthetic result was sufficient to effect an improvement in the patient's self-esteem, whereas the teeth in Case 1 remained imbricated with the patient being satisfied with the result. The results in Cases 3 and 4 achieved an esthetic result, which was superior to that achieved in Cases 1 and 2, but this was partially as a result of the preoperative position of the teeth and what the patient was prepared to accept.

There is also the challenge of carrying out this treatment in a biologically sound manner. In this respect, the use of adhesive nondestructive composite restorations for the treatment of TSL, or other esthetic problems, represents a viable, biologically sound treatment modality in which substantial improvements in dental appearance may be made (Figures 7A and B). The results of such treatments offer high degrees of patient satisfaction[46] with no potential for pulp death. The results may not concur with the various "rules" of tooth form, but as discussed (*vide supra*), there is presently little consensus among dentists, except that the maxillary central incisor teeth should be symmetrical. An attempt to achieve was made in the cases presented, each of which presented varying degrees of tooth destruction due to TW and also with patients accepting varying degrees of esthetic improvement. The treatments described are not without risk of discomfort to the patient, although, being minimally invasive, can generally be carried out with minimal or no anesthesia. However, patients must be informed of the potential disadvantages of treatment as detailed for Case 1. In this regard, although the time for reestablishment of the posterior occlusion may vary between 6 weeks and 6 months, in practical terms, many patients adapt much earlier than this. However, it may still be considered sensible to build in a bit of leeway and to stress, well in advance of any treatment, that the patient has to learn to adapt their eating in order to solve their own problem.

Regarding the longevity of the resin composite restorations, the patient should be advised that these may require occasional finishing and polishing, and that occasional chipping (Figure 8) or partial debonding (*vide infra*) is a possibility, possibly because of the habits that caused their presenting problems and because bonding has not yet reached its ultimate in terms of development. In addition, at the time of placement of the restorations, the patient should be asked to check restorations with his/her tongue to ensure that there are no rough edges and should be advised that the final occlusal adjustment and polishing with diamond paste will be carried out at a second visit 1 week later.

The success of the treatments described has been reported by a number of authors. Among the first papers to describe this treatment was that by Hemmings, Darbar, and Vaughan in 2000.[46] Severe TSL

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FIGURE 7. A and B, Preoperative presentation of a patient suffering from severe TSL. C, Patient in (A): Substantial improvement in dental appearance may be made. It is not perfect—the concept of Pragmatic Esthetics (A, B, and C reproduced by permission of George Warman Publications Ltd., Guildford UK, publishers of *Dental Update*).

FIGURE 8. Slight (reparable) fracture/debond of restoration in UR1.

was treated for 16 patients using a total of 104 adhesive resin composite restorations placed at an increased occlusal vertical dimension, causing disclusion of the posterior teeth of 1 to 4 mm. Two sets of materials were used: group A: Scotchbond Multipurpose dentine-bonding agent (3M ESPE) and Durafill composite (Heraeus Kulzer) and group B: Optibond as bonding agent, with Herculite XRV (Kerr Manufacturing, Orange, CA, USA). It was found that the occlusion was fully restored in a mean time of 4.8 months (range 1–11 months), and 89 of the restorations remained in service after 2.5 years, with all but 6 of the 39 failures being in group A. It was concluded that resin composite restorations placed at an increased occlusal vertical dimension may be a treatment option for the treatment of localized anterior TSL.

More recently, Poyser and colleagues[47] in a randomized, split-mouth controlled clinical trial, evaluated the performance of 168 Herculite XRV (Kerr Manufacturing) restorations bonded to the worn anterior teeth of 18 patients. Restorations increased the occlusal vertical dimension by between 0.5 and 5 mm, and the restorations were examined by five independent and calibrated examiners at a mean time of 2.5 years. The results indicated the following:

1 Failure of the restorations, due to bulk loss, was only 6%.

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2 Occlusal contacts were restored after mean time of 6.2 months, but 1/3 of "Dahl" patients had not completed reestablishment.
3 Mean time per tooth was 11 minutes.
4 Periodontal health improved.
5 No teeth treated required endodontic therapy.
6 No temporo mandibular joint (TMJ) pain in any patients.
7 Very high level of patient satisfaction.

The authors concluded that "direct composite restorations have distinct biological advantages compared with crowns, and for the majority of patients they perform well, offer a high degree of patient satisfaction and require an acceptable level of maintenance." Patient accommodation to the technique was good. There was no detrimental effect on TMJ, periodontal or pulpal health, and bulk fracture and failure were uncommon. Other papers report similar findings.[48,49] Most recently, an International Association for Dental Research abstract/paper[50] has reported on 18 patients in The Netherlands whose TW was treated with direct composite restorations ($N = 338$) placed by one operator. Retrospective assessment was carried out at up to 11 years. Patient satisfaction was tested on a visual analogue scale (VAS), with high patient satisfaction being noted both at the time of treatment and at the final examination. Eighteen restorations showed failures (5.3%), although 10 of these did not need a restorative intervention. Kaplan–Meier analysis showed an annual failure rate of 1.4%.

In the present authors' experience, chipping or partial debonding appears to occur most frequently in teeth with no, or minimal, enamel at the margins of the worn surfaces (which is to be expected), but the majority of problems are restorable (Figure 7). As reported by the research presented above, patient satisfaction is high. The authors generally offer patients a review at 3 months post-treatment, at which time their satisfaction with their dental appearance is discussed, with crown-lengthening surgery and all-ceramic crowns being offered if the patient is not satisfied with the pragmatic esthetic result, which has been offered. However, it is the authors' view that the number who avail themselves of such additional treatment is less than 5%.

Finally, the treatments described fit comfortably within the concept of the Daughter Test,[51] namely, "would you carry out this treatment on a loved one, colleague or friend." There is no additional damage caused to the already damaged teeth, and although the appearance may not always achieve the esthetics which may be achieved by multiple crowns or veneers, it is pragmatic, or at least as good as can be achieved within the biologic principles of maintaining pulp vitality and periodontal health, while still achieving good patient satisfaction and maintaining a good fallback position should a restoration subsequently fail. The Hippocratic exhortation of "Firstly do no harm" is central to this approach. The phrase "expect the best, but plan for the worst!" may also be considered appropriate.[52]

CONCLUSION

Resin composite restorations, bonded using an etch-and-rinse dentine-bonding agent, may provide reliable restorations for worn teeth. The esthetic result may not conform to the highest principles of dental esthetics, but represent an effective way of protecting teeth from further TSL, while effecting an improvement in patient-perceived esthetics. This is the concept of *pragmatic esthetics*.

DISCLOSURE STATEMENT

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