Treatment of extended anterior crown fractures using Type IIIA bonded porcelain restorations (part one)

By Pascal Magne, DMD, PhD, and Michel Magne, CDT

ABSTRACT
Novel-design bonded porcelain restorations, the so-called Type IIIA BPRs, represent a reliable and effective procedure when restoring large parts of the coronal volume and length in the anterior dentition. While traditional treatment approaches involve the removal of large amounts of sound tooth substance (with adverse effects on the pulp, gingivae and crown biomechanics, as well as serious financial consequences), the use of adhesive technology instead can provide maximum preservation of tissues and limited costs. Considerable advantages, such as the economical and non-invasive treatment of crown-fractured teeth, are inherent to Type IIIA bonded porcelain restorations, reducing the need for preprosthetic interventions (eg root canal therapy and crown-lengthening) and the use of intraradicular posts. This article, illustrated with cases with up to eight and 10 years' follow-up, sets the scientific foundations of this concept, as well as important considerations about function, strength, tooth preparation, laboratory technique, and bonding optimisation.

It is generally agreed that bonded porcelain restorations such as porcelain veneers have matured into a predictable restorative concept in terms of longevity, periodontal response and patients' response (Calamia 1989, Kourkouta et al 1994, Pippin et al 1995, Meijering et al 1997, Peumans et al 1998, Fradeani 1998).

Owing to intrinsic favourable aesthetics in the marginal area, bonded porcelain restorations do not specifically require penetration into the gingival sulcus, which prevents potential damage to the periodontal tissues and biologic width violation. Feldspathic porcelain is also known as being less susceptible to accumulation of bacterial plaque in comparison to gold, resin or even to hard tooth structures (Chan et al 1986, Koidis et al 1999). The indications for the use of bonded porcelain restorations broadened significantly during the 1990s as a number of researchers expressed confidence in these restorations (Andreasen et al 1991, Andreasen et al 1992, Magne et al 1993, Walls 1995a, Walls 1995b, Belser et al 1997). As a result, innovative preparation designs emerged (Magne et al 1993, Belser et al 1997, El-Sherif and Jacobi 1989). Internal stress distribution and the parameters responsible for postbonding cracks formation were investigated, and preparation design rationalised accordingly (Highton et al 1987, Magne and Douglas 1999a, Magne and Douglas 2000, Magne et al 1999a). Unexplained craze lines, which initially deterred clinicians from using porcelain veneers, were understood and explored experimentally (Magne et al 1999a, Barghi and Barry 1997, Magne et al 1999).

Based on these considerations, restoration of extensive crown fractures (see Figures 1-3) have been proposed among indications for bonded porcelain restorations, the so-called Type IIIA bonded porcelain restorations according to the classification by Belser and Magne (Belser et al 1997) (Table I, Figure 1). This

Pascal Magne, DMD, PhD is associate professor with tenure, and chair of aesthetic dentistry, Division of Primary Oral Health Care, at the University of Southern California School of Dentistry.
Michel Magne, CDT is an associate professor and director of the Center for Dental Technology at the Oral Health Center, University of Southern California School of Dentistry, and a consultant for Straumann, Waltham, Massachusetts, USA, and Zhermack, Badia Polesine, Italy

Classification of indications for porcelain veneers
TYPE I TEETH RESISTANT TO BLEACHING
GROUP IA Tetracycline discolouration of degrees III and IV GROUP IB Nonresponse to external and internal bleaching
TYPE II MAJOR MORPHOLOGIC MODIFICATIONS
GROUP IIA Conoid teeth GROUP IIB Diastemata and interdental triangles to be closed and reduced GROUP IIC Augmentation of incisal length and incisive prominence
TYPE III EXTENDED RESTORATIONS (ADULTS)
GROUP IIIA Extended crown fractures GROUP IIIB Extended loss of enamel by erosion and wear GROUP IIIC Generalised malformations and acquired deformities

Table 1

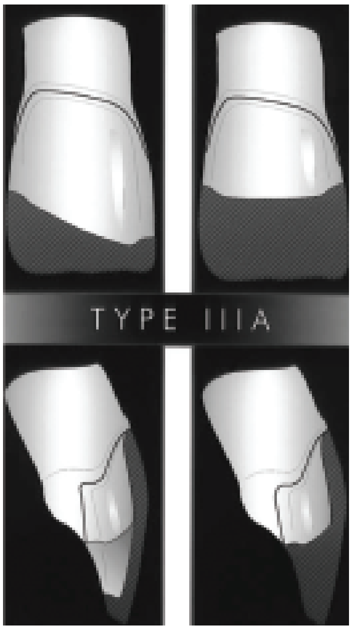

Figure 1: Indication Type IIIA represents a novel-design porcelain veneer for which the veneer includes the missing part of the incisal edge as well as the facial surface

approach, used by the author for more than 12 years, has to be considered with special attention because its success and reliability can result in considerable improvements, comprising both the medical-biological aspect (ie economy of sound tissues and maintenance of tooth vitality) and the socio-economical context (ie decrease of costs when compared to traditional and more invasive prosthetic treatments) (Magne and Douglas 1999b). Theoretical bases for such an indication have been documented by experimental and numeric studies demonstrating the sufficient strength and adequate biomechanical behaviour of the tooth-restoration complex, provided that adequate design and thickness of the restoration are respected (Andreasen et al 1991, Andreasen et al 1992, Magne and Douglas 1999a, Magne and Douglas 1999b, Magne and Douglas 1999c). The clinical performance of these novel-design porcelain veneers was confirmed in a mediumterm clinical trial (Magne et al 2000). Because traditional porcelain veneers are expected to last 10 to 15 years, these clinical results can be considered only as preliminary (Friedman 1998). However, bearing in mind that 100% of the restorations survived over the average 4.5-year period, a very good prognosis can be anticipated for the new proposed indication. For those incisors with extensive loss of coronal tissues (see Figures 2 and 3), traditional treatment approaches would have involved the removal of large amounts of sound tooth substance, with adverse effects on the pulp, gingivae, and crown biomechanics, as well as significant financial consequences. Using adhesive technology instead of traditional mechanical retention can provide maximum preservation of tissues and limited costs, which also contributes to the absolute satisfaction of the patients. Using Type IIIA bonded porcelain restorations, fractured teeth that are vital before treatment can be kept vital during and after treatment despite considerable hard tissue breakdown. From the periodontal perspective, an additional significant advantage of bonded porcelain restorations is the avoidance of crown lengthening procedures because even very short clinical crowns can be restored (see Figure 2).

Further, the overall behaviour of Type IIIA bonded porcelain restorations can be most predictable when adequate treatment planning is carried out. In this regard, high success rates in restoration survival and the patient's satisfaction are also certainly due to the use of additive wax-ups, silicon guides and corresponding diagnostic templates (acrylic mockups) (Magne and Douglas 1999d, Magne and Belser 2004). These strategic elements facilitate three significant steps of the procedure: (1) maximum respect of the patient's desire in the definition of the final functional and aesthetic goal; (2) maximum respect of the remaining thickness of enamel during tooth preparation; and (3) restoration of the original enamel thickness and biomimetic recovery of the crown (see next section).

Considerations about strength

In the veneer technique, the use of porcelain, instead of composite resins is instrumental in the way patients perceive the treatment as demonstrated in a clinical study by Meijering et al (1997). Additionally, porcelain also acts as the most 'biomimetic' material when it comes to the replacement of significant amounts of tooth substance, perhaps because of its ability to simulate and restore crown rigidity (Magne and Douglas 1999e, Magne and Douglas 2000). Owing to their high thermal expansion and elasticity (dentin-like elastic modulus of 10-20 GPa), composite veneers are not able to achieve such goal, which seems to yield unfavorable aesthetics, unstable marginal integrity and decreased survival rate (Reeh and Ross 1994, Lacy et al 1992, Kreulen et al 1998, Meijering et al 1998). On the other hand, even traditional porcelains such as basic feldspathic materials (enamel-like elastic modulus around 70GPa), are able to compensate for structural tooth weakness. When used in the form of bonded veneers, they can contribute to the recovery of crown biomechanics, including nonvital incisors (Magne and Douglas 2000). When pulpless teeth are treated with traditional prosthodontic procedures (instead of the more conservative veneering techniques), various types of dowels and cores are commonly recommended. This in turn may generate numerous complications, such as cracks and root fractures. It is now established that both the biomechanical properties and the moisture content of nonvital teeth do not differ significantly from those of vital teeth (Sedgley and Messer 1994, Papa et al 1994). The loss of tooth structure thus becomes the primary cause of

*Figure 2: Typical case of extreme fracture for indication Type IIIA (2a). Teeth are vital, and because of adequate treatment planning (additive wax-up technique), only a thin layer of the existing enamel was removed during tooth preparation (2b). Feldspathic porcelain restorations were fabricated with a refractory die technique using a significant core of opaque dentin covered with regular dentinoenamel porcelains (2c). Note the use of an opaque dentin build up, which proves essential in blending the unsupported porcelain edge with the remaining cervical part of the restoration. Clinical view after 10 years of successful service (2d). Note the excellent periodontal response, as well as the absence of detectable wear of the antagonistic dentition despite the restoration of significant guidance. The patient slightly overbleached the aging intact dentition using bleaching strips from her own initiative in order to maintain this result. There are some stains on the palatal surface (mainly on enamel), but no infiltration and no detectable decay (2e). Figures 2a and 2b, reprinted with permission from Int J Peiodontics Restorative Dent **20(5)**:441-57, 2000*

failure, not the effect of pulp removal per se. Except in cases of endodontically treated teeth with total breakdown of coronal tooth substance, there is currently no evidence that contraindicates veneering non-vital teeth with Type IIIA bonded porcelain restorations.

The extensive incisal edge span of the ceramic material represents the main challenge of Type IIIA indications. Wall et al demonstrated that up to 2mm of incisal edge span of ceramic could be created on lower incisors without affecting the ultimate coronal strength (Wall et al 1992). Andreasen et al may have been the first authors to advocate the treatment of crown-fractured incisors with bonded porcelain restorations in the early 1990s using Dicor porcelain (Andreasen et al 1992). This invitro investigation surprisingly claimed ultimate coronal strengths of restored teeth far exceeding that of intact teeth. This conclusion might be more accurate today considering the progress of dentin adhesives and new application modes (see section 'Bonding strategy', part two, May *Private Dentistry*) (Magne and Douglas 1999e). It was clearly demonstrated that the potency of the concept lies in the design of the restoration, which is explained through favourable load configuration, geometry and tissue arrangement of upper incisors (Magne and Douglas 1999a, Magne et al 1999c). As a consequence, coronal strength has proven to be sufficient even when using feldspathic bonded porcelain restorations with extensive incisal edge spans of porcelain. Clinical data are supportive because no clinically relevant alterations have been detected up to 5.5mm of average freestanding feldspathic material (Magne et al 2000). When compared to intact teeth, bonded porcelain restoration-restored

Figure 3. Other case with similar approach as in Figure 2. The incisal edge span of porcelain in the mesial part of 1| is more than 5mm (3a). Note the outstanding integration of the two bonded porcelain restorations even after eight years of clinical service (3b)

crowns featuring extensive incisal edge spans of ceramics are characterised by their 'low-stress' design and increased crown stiffness (Magne and Douglas 1999c).

Tooth preparation

Tooth preparations principles for Type IIIA bonded porcelain restorations do not differ much from those applied in traditional veneer preparations. The adhesive properties and physicochemical characteristics of the luting composites allow the tooth restoration interface to be subjected to substantial stresses. From this viewpoint, the geometric and mechanical parameters of the tooth preparation are of secondary importance. A minimum amount of preparation geometry however, is still required to facilitate placement and positioning of the ceramic workpiece during the final bonding procedure. In the cervical and proximal areas, the creation of a light chamfer margin without internal line angles is universally accepted. A new simplified porcelain laminate preparation driven by an acrylic mock-up was developed and can be applied to the remaining facial cervical third of the fractured tooth (Magne and Belser 2004). In all cases, an additive diagnostic waxup restoring the original volume of the tooth is used as a reference for tooth reduction. This basic principle will save a significant amount of sound tissue, not only enamel, but also the critical dentinoenamel junction (Magne and Doulgas 1999d). It is essential to produce preparations without sharp angles, considering that the improved quality of both the preparations (sufficient clearance for the ceramic, smooth contours, absence of undercut) and the final impressions will significantly facilitate the work of the dental ceramist, leading to minimal use of die spacer and thus reducing the risk of postbonding cracks (Magne et al 1999a, Magne et al 1999b, Barghi and Berry 1997).

The dilemma of Type IIIA bonded porcelain restorations lies in the fact that the palatal finish line is often localised in palatal fossa, which constitutes a zone of maximum tensile stresses (Magne et al 1999c). In this context, the extent of tooth substance loss must be considered because it will significantly influence the location of the palatal finish line. Different patterns of stress are expected on the palatal margin of the veneer depending on the original level of the fracture line (eg moderate fracture through the palatal concavity versus extensive fracture through the tubercule of the cingulum) (Magne and Douglas 1999a). In moderate fractures (incisal 1/3), a palatal mini-chamfer is contraindicated as it would extend the restoration margin in an area of high stress. In such a case, a butt margin limits the extension of the ceramic, thus reducing the amount of stress at the restoration interface and increasing the strength of the tooth restoration complex (Magne and Douglas 1999a, Castelnuovo et al 2000). The use of a butt margin also provides the margin of the restoration with a strong bulk of porcelain, instead of creating a thin marginal extension of ceramic as with a palatal chamfer. For severe crown fracture (incisal 2/3), the palatal margins are subjected to low tensile forces because they are located in the low stress area of the cingulum. The latter, with its smooth convexity, can be combined either with a butt margin or a mini-chamfer without generating harmful stresses (Magne and Douglas 1999a). ■

References and aknowledgements

The authors express their gratitude to Professor Terrence Donovan, chair, Division of Primary Oral Health Care, USC School of Dentistry, for reviewing the English draft.
For a full list of references to accompany this article, please email the editor at sarah.manolescue@fmc.co.uk.
Part two of this article will feature in the May issue of *Private Dentistry*, but if you would like to hear the authors lecture, book your place at the World Aesthetic Conference to be held on 9 and 10 June. Call Independent Seminars on 0800 371652 for more information.