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10.5005/jp-journals-10015-1036

REVIEW ARTICLE

Rectifying the Tooth Preparation Errors in All-Ceramic Restorations

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ABSTRACT

All-ceramic restorations have been used for long as restorative material in dentistry. However, the recent advances in both the material and technology of all-ceramic have made them a more viable treatment option. Several practitioners hesitate in giving this option to patient for fear of failure. This article describes all the failures of all-ceramic material and how to prevent them. In particular, the article highlights various errors that clinicians make while preparing tooth to receive all-ceramic restorations and how to rectify them.

Keywords: Prosthodontics, Tooth preparation, All-ceramic, Ceramic failures.

INTRODUCTION

Dental ceramics have come a long way from its nascent days of low-strength ceramics being used for laminate veneers and bonded with poor adhesive to modern day high strength ceramics used both for anterior and posterior full veneers. We have witnessed a phenomenal improvement in both the material and technical aspect of dental ceramics.[1,2] All-ceramic crowns have been extensively used in prosthodontics in recent years for their superior gingival response and esthetic quality while achieving similar marginal accuracies when compared to traditional metal based restorations.[3,4] Today no other material can surpass the esthetics of all-ceramics and with the advent of zirconia its coping strength is good too.[5,6] CAD-CAM technology has enabled the fabrication of crowns and fixed prosthesis in a rapid and predictable manner.[7]

Inspite of all these advancements, most clinicians shy away from the material due to lack of knowledge or information regarding the material. There is a high dependence on the laboratory technician's knowledge and the treatment becomes laboratory guided.[8] Most failures in all-ceramic can be avoided by understanding the properties of the material and accordingly preparing the tooth and handling the laboratory procedures.

The aim of the article is to enumerate the causes of failure of all-ceramic restorations, describe in detail the errors during preparation and suggest measures to rectify the same.

Ceramic Failures

Like most other materials in dentistry, all-ceramic is also not failure proof. Failures can occur due to a number of reasons like poor case selection, faulty preparation, inaccurate impression, improper material handling, etc.[9] Ceramic failures can be broadly classified as:[10]

Mechanical Failure

Longitudinal clinical studies, spanning more than 10 years and evaluating the mechanical properties of glass ceramic crowns and densely sintered alumina core, have shown results similar to metal ceramic crown.[11,12] However, all-ceramic crowns do show mechanical failures. Mechanical failure will be seen as:

a. Fracture of abutment
b. Chipping or fracture of ceramic
c. Debonding.

Proper case selection is paramount to success of any clinical procedure. Predisposing factors for the occurrence of fracture of all-ceramic include heavy functional and parafunctional loading.[13] All-ceramic restorations are contraindicated for edge to edge and crossbite occlusal relationship because of excessive stress during function.[14] It is also contraindicated in patients where opposing tooth occlude on cervical 1/3rd of lingual surface as the tensile stress created will lead to half moon fracture.[15]

The strength of ceramic restoration increases with effective bonding between tooth structure and ceramic. Bonding with adhesive cement substantially diminishes the internal surface defects in ceramic, thereby reducing potential fracture. Three together form a single structural unit in which one reinforces the other just like dentin reinforces the enamel.[16] The cement selected for all-ceramic restoration should exhibit sufficient flexural strength, flexural modulus and fracture toughness.[17]

Biological Failure

Biological failures observed following cementation of the restoration. Biological failures are seen in the form of:

a. Postoperative sensitivity
b. Marginal microleakage.

These failures are due to inaccurate fit and improper bonding of the restoration.[18] Tooth preparation for bonded restoration, including ceramic veneers should be restricted to enamel because extensive exposure of dentin can reduce bond strength and encourage microleakage.[19] Microleakage has routinely been shown to be more pronounced when the preparation margin is in dentin and even when depth guides allow 0.4 to 0.6 mm reduction, dentin is often exposed in cervical area.[20,21] Postoperative sensitivity is now uncommon as the modern day self-adhesive cements do not have an acidic component, and hence sensitivity is less. There have been major developments in dentin surface treatment in preparation for bonding and in the chemistry of bonding agents. It is anticipated that with new dentin bonding systems and application techniques the incidence of postoperative sensitivity may decline further. When self-adhesive procedure is used in conjunction with clinically proven resin cements, the chances for long-term success will be further improved.

Esthetic Failure

This is the only failure, which the patient is highly aware of and will not accept. The various esthetic failures can be categorized into:

a. Poor shade selection
b. Visible margins
c. Poorly camouflaged discolored tooth.

Esthetic failure can happen either at the clinician's end due to improper shade selection or at the technician's end due to improper shade execution. Some failures are seen over a period of time due to gingival recession and poor show of the margins. To avoid this failure, patient must be trained in proper oral hygiene maintenance of the ceramic veneer with periodic dental check-ups. Proximally, one must take the preparation margins as lingual as possible in order to avoid marginal show due to interdental papilla recession.

TOOTH PREPARATION ERRORS IN ALL-CERAMIC RESTORATIONS

Tooth preparation done following the principles or guidelines of tooth preparation forms the foundation for clinical success in all-ceramic restorations. Next to inadequate impressions, errors in tooth preparation are the most serious challenges facing laboratory technicians.[22]

The following are the most commonly seen errors during tooth preparation for all-ceramic restorations and precautions to be taken to rectify them.

Sharp Line Angles

Leaving behind sharp line angles and point angles in the preparation can lead to major fit problems and time consuming appointment at the time of cementation. Sharp line angles form potential sites for fracture stimulation of all-ceramic restoration[22-25](Fig. 1A). The solution is simple. One must round off all the sharp line angles and point angles at the time of tooth preparation (Fig. 1B).

Clinician often tends to underestimate the importance of smooth internal line angle lying at the junction of axial walls and margins. A sharp internal line angle can cause undue stress, initiate fracture and may cause fit problems[23,24] (Fig. 6). To prevent this problem, it is advisable to use a flat end diamond with built in round edges, which automatically creates a rounded internal line angle while creating a shoulder margin.

Margins

Beveled or Feather Finish Lines

Beveling of margins or creating a feather edge margin is contraindicated for all-ceramic preparations. To fabricate an all-ceramic restoration over beveled finish lines is near impossible for the laboratory technician. Even if one is able to manage fabricating it, such a restoration has high chances of failure during seating in the form of chipping or bulk fracture.[22,23] For pressable ceramic, shoulder is required for strength at the margins because marginal area bears much support of the crown in function (Fig. 2). This is because the best adaptation of the crown is found at its cervical aspect while

Fig. 1A: Sharp line angle and point angle

Fig. 1B: Rounded line angle and point angle

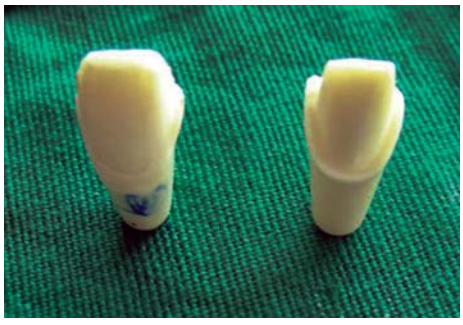

Fig. 2: Feather margin compared to shoulder

Fig. 4: J margin

Fig. 3: Rough shoulder

Fig. 5: Nonuniform shoulder

internal adaptation is poor at the remaining areas of the prepared tooth. While using CAD-CAM technology, all-ceramic preparation with well-defined chamfer is preferred as the material used, i.e. alumina or zirconia cores are inherently strong and do not require bulk of material for strength as is true for conventional ceramics.

Rough Shoulder

Rough shoulders are not just difficult to record but also difficult for the technician to work on. They contribute to unnecessary build-up of stresses at the margins. A smooth shoulder ensures an excellent fit, minimal cement line and good esthetics. Also, undue stress at the margins arising from rough shoulder is avoided (Fig. 3). An end-cutting diamond must be run over the margins at the end of the preparation to smoothen the margins.[26]

J Margin

Overzealous preparation of a chamfer margin can lead to what is called a J margin with unsupported enamel lip[23] (Fig. 4). This happens when the operator goes deeper than the width of the head of diamond creating a groove.[27] Such a margin is difficult to scan for a CAD-CAM procedure. A "J" margin is not acceptable as it leads to thin ceramics at the margin, which is susceptible to fracture. One should be cautious as to not go deeper than the head of diamond while preparing the margins.

Incomplete and Nonuniform Shoulder

If the width of the shoulder varies from one region to another, it can vary the ceramic thickness with a potential for premature

Fig. 6: Sharp internal line angle

fracture during fabrication, seating or cementation[23] (Fig. 5). This can also cause an undesirable esthetic failure. To avoid this failure, one must prepare a uniform shoulder of 1 to 1.5 mm all around the tooth.

Pseudoshoulder

This is created when the operator loses orientation to the proper plane of reduction and angulates the head of the diamond too deep into the margins (Fig. 7A). The end result is a deep undercut and not a shoulder.[23] Although it appears as a shoulder in one plane it is a false appearance. A pseudoshoulder can diminish both the strength and esthetics of the ceramic (Fig. 7B). Use of depth orientation groove will keep the operator oriented to the right plane of reduction.

Overshortening of the Preparation

In a full veneer crown, whenever load is applied from a lingual direction, the labial marginal ceramic is placed under

Fig. 7A: Faulty orientation of the diamond

Fig. 7B: Pseudoshoulder

compression. This compressive stress can be resisted only by adequate length of abutment. Hence, we should be cautious not to over-shorten the crown.[25] Ideally incisal edge should be reduced by 2 mm or 1/3rd the length of the crown. Incisal edge should not be made thin, rather it should be prepared flat and placed at right angle to the direction of forces.

Inadequate Preparation of Axial Walls

Some dentists use small, round-ended, tapered or flame-shaped diamonds for reduction of the medial, distal, lingual, and even facial walls of tooth preparations for crowns. This results in minimal reduction of tooth structure and creation of feather-edge margins. Although this type of preparation is adequate for all metal restorations, it is not acceptable for metal ceramic and all-ceramic crowns because it leaves inadequate thickness for both substructure and veneering ceramic. Inadequate axial tooth preparation forces technician to make overcontoured crowns and compromises both esthetics and self-cleansing design of the restoration.[22]

Inadequate tooth preparation often occurs due to the inherent fear of pulp exposure of the dentist. Knowledge of tooth anatomy and sound clinical judgment can allay these fears. Copious water spray should be used during tooth preparation procedure. Whenever a white residue accumulates on the tooth surface during preparation, inadequate water spray should be suspected and supplemental water spray should be delivered by the dental assistant to clear the operating field and preserve the vitality of the pulp.

Excess Taper of the Prepared Tooth

The degree of taper of the preparation has been a subject of debate for long. Prior to the advent of resin cements, the dentist had to largely depend on a good retentive form to retain the crown in place. Today, with resin cements, the scenario has changed. Achieving near parallel surfaces is not considered critical anymore, as these cements bond very well to tooth surface. However, the taper of the prepared tooth should not exceed 8 or 10 degrees from the long axis of the tooth. When cements that do not bond to tooth structure are used, it appears to be logical that the preparations should be made more parallel. When it is not possible to create near parallel axial walls, crown lengthening or placing parallel vertical retentive grooves in the tooth preparation or both are advocated.[22]

Over reduction of Tooth Structure

Over reduction is another mistake that dentists often tend to make. It makes the laboratory work easier and allows optimum esthetics and strength of the restoration, but the damage caused to the dental pulp is unpardonable. The rule of thumb should be to remove only as much tooth structure as required. The lack of retention and reduction in the inherent strength of the remaining tooth structure are apparent disadvantages.[22]

Having knowledge of how much to reduce for each type of all-ceramic material and choosing the right material for a particular clinical situation will help prevent over reduction. While preparing anterior teeth placing depth orientation grooves help in deciding both the depth and plane of reduction.

Inadequate Occlusal Reduction

Inadequate preparation is as harmful as over preparation. Both lead to failure in the long-term. Inadequate occlusal reduction will provide insufficient space for the bulk of ceramic leading to weak areas prone to fracture.[22,23] Using flexible clearance tabs to check for adequate occlusal reduction will avoid this problem.

Lack of Uniform Anatomic Reduction

Uniform multiplane reduction should be patiently done to get the best strength outcome from the material. Teeth should be uniformly reduced, thereby enhancing the potential for normal crown form and improved esthetic results.[24]

Laminate Veneers

There are few important points one must note when it comes to all-ceramic laminate veneers. In most part all the aforementioned key points are applicable to a laminate preparation as well. In addition, one must take care of following aspects during preparation.

a. Most fractures are cohesive in nature. These happen due to inadequate preparation, maladjusted occlusion and/or parafunctional habits.[28]
b. Faulty occlusal stops can result in flexural stress during protrusion and cause fracture of the laminate. In patients with bruxism if the occlusal stops are not well planned, the tooth can wear faster than the ceramic leaving a very fragile unsupported ceramic edge.[29,30]
c. The preparation is to be designed to restrict flexural stresses. Sufficient lingual clearance allows ceramic to work in compression.
d. It is necessary to increase the thickness of incisal preparation and always cover the incisal edge. Fracture rate is highest in laminates without incisal coverage, especially in canines and premolars where shear stress is at its peak.[28]
e. On the palatal surface, the preparation should end in a palatal mini-chamfer or butt joint.[31]
f. Minimal thickness of luting composite must not exceed 1:3 ratio to ceramic thickness.[32]
g. Management of the antagonist contact on maxillary natural tooth structure can reduce the risk of fracture.[33]

CONCLUSION

Failures in all-ceramic restorations are not uncommon. Unfortunately, one or two such failures are enough to discourage the clinician from using the material entirely. The failures arising due to errors during tooth preparation are entirely the responsibility of the dentist and can be easily avoided by following adequate care. Sound working knowledge, good clinical judgment in case selection and execution of the planned treatment will ensure success. To a large extent knowing the material properties and keeping abreast with the recent trends and current innovation will help reduce chairside time and yet help one deliver good treatment with predictable success.

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