In attempting to provide a restorative solution for cases that have been compromised by spatial considerations, clinicians have traditionally opted for an orthodontic approach that did not provide optimal aesthetics due to changes in tooth morphology, specifically tooth size and shape as a result of dental deterioration. With the advent of contemporary aesthetic materials and preparation techniques, clinicians and technicians are now empowered to deliver a penultimate result with minimal compromise to the surrounding dentition. This article presents the clinical and laboratory considerations that must be addressed when providing a prosthetic restoration for crowded teeth.

Learning Objectives:
This article discusses an option outside of orthodontics in the restoration of cases that are compromised by spatial considerations. Upon reading this article, the reader should:
• Be able to address the clinical factors needed with spatially compromised cases.
• Understand laboratory considerations in the restoration of such cases.

Key Words: orthodontic, aesthetic, space, tooth proportion
Orthodontic therapy represents an excellent, predictable means of achieving tooth movement to address aesthetic and functional concerns. Most patients can benefit functionally and aesthetically from orthodontic therapy. This is particularly true in patients who present with a crowded smile (dentition), commonly marked by overlapping and misaligned teeth. The benefits of orthodontic therapy from a periodontal, restorative, and cosmetic point of view are well-documented.1 Periodontal defects can be reduced, and restoratively compromised teeth can be salvaged through orthodontic forced eruption.2 This technique is used to correct cosmetic midfacial soft tissue discrepancies in the gingival architecture.3 It enhances aesthetics by reestablishing proper tooth proportions and altering the location of the midfacial and interproximal gingival tissues, often called the interdental papilla.

Innovative materials (eg, temperature-sensitive/activated archwires, ceramic brackets), combined with new techniques in contemporary orthodontic therapy, have led to the development of aesthetic and efficient treatment devices as well as streamlined treatment times. These developments have given rise to a greater level of acceptance of orthodontics in the adult patient population.

Even with these advances in treatment, some patients may refuse orthodontic therapy due to occupational limitations of time and appearance during treatment. The development and introduction of removable, acrylic-based orthodontic aligners has increased patient acceptance, particularly those resistant to fixed appliances. Although treatment with aligning appliances has many benefits, there are limitations as well. In addition, some questions have been raised with respect to stability of treatment outcomes, specifically, long-term retention of rotational corrections present in the crowded dentition postoperatively.4 The potential for orthodontic relapse has inspired the use of tooth preparation and restorative dentistry to recreate tooth dimensions and proportions commensurate with postorthodontic results from both an aesthetic and functional clinical outcome, thereby eliminating the potential for relapse and the need for forced orthodontic tooth movement.5
Restorative Space Management (RSM) is defined as therapy that uses tooth preparation techniques and designs to accomplish the goals of orthodontic therapy. It requires selective and strategic removal of tooth structure and the addition of cosmetic restorative materials (e.g., direct/indirect restorations). Unlike traditional orthodontic therapy, the benefits of RSM include correction of tooth shapes and dimensions that improve tooth proportions, as well as color correction, concomitantly.

The goals of therapy for the orthodontist and restorative dentist are similar; however, they achieve the results in a different manner. The orthodontist achieves his or her goals through tooth movement, while the restorative dentist performs reconstructive dentistry by tooth restoration. The quantity of tooth structure removed must be defined and limited to avoid subsequent problems associated with overly aggressive removal of uncompromised tooth structure.

Biologic and Structural Parameters

The parameters for RSM are defined by the dimensions and structures of the teeth and surrounding periodontium within the dental arches. There are limits to the degree of tooth structure that can be removed before pulpal and periodontal violation result. Since the pulpal chamber size decreases with age, this parameter is influenced by the individual characteristics of each case and the age of the patient. Excessive tooth removal to accomplish the goals of therapy may require mutilation of the remaining tooth structure, thus compromising the biologic and structural outcomes from three essential aspects: endodontic instability regarding questionable pulpal health and long-term prognosis of root canal treatment; structural instability of the remaining tooth structure to support the restoration and/or occlusal scheme; and periodontal instability caused by resultant changes in restorative tooth morphology (e.g., unfavorable proximal contours that could impede proper oral hygiene and encourage food impaction and plaque retention). One must consider the aforementioned guarded consequences.
afforded by such therapy without regard for the aesthetic and functional effects. In addition, negative gingival and interdental papilla architecture cannot be remediated through RSM treatment.

### Treatment Planning

Tooth crowding can pose an intellectual and technical challenge, since both mesiodistal and buccolingual discrepancies must be addressed. Resultant periodontal instability can be more of a contraindication in these cases. The objectives of RSM therapy in a case with insufficient space are to restore proper tooth proportions and establish a stable physiologic occlusion. Ward identified the “recurring esthetic dental” or RED proportion, which is the width-to-length proportion of the maxillary teeth that falls between 75% and 80%. Invariably, this requires the creation of space to straighten the anterior dentition. The resultant “Tooth Proportion” formula is as follows:

\[
\text{Tooth Proportion} = \frac{\text{Width}}{\text{Length}},
\]

which should fall in the 75% to 85% range, in order to be considered aesthetic. In such instances, the clinician must assess where the necessary space can be gained to accomplish the treatment objectives by reducing existing structures rather than shifting the dentition orthodontically.

Space is frequently gained by preparing the posterior teeth in ways that require removal from the mesial aspect and addition to the distal aspect. Moderate crowding can often be successfully treated using this technique. An average of 1 mm to 1.5 mm of total reduction per tooth can be comfortably obtained due to the interproximal contours of teeth and the anatomy of available enamel. When multiplied by the number of teeth involved, the result should give adequate space to realign the crowded dentition.

Buccolingual changes in tooth position can be associated with discrepancies in gingival architecture (e.g., midfacial tissue height, papilla height, papilla shape) that require adjunctive periodontal therapy or orthodontic correction. Mild to moderate discrepancies, such as Class I and Class II case types, are easily and predictably treated by RSM. Severe case types, such as Class IV, could require tooth mutilation as well as significant periodontal therapy (i.e., crown lengthening), which would be a contraindication to RSM treatment.

Class III case types frequently require adjunctive orthodontic and/or periodontal therapies and may require elective endodontics in borderline cases in order to correct the functional and aesthetic deficiencies. Class IV case types cannot and should not be treated without orthodontic and periodontal consideration (Table).
Space Management Case Classification

Patients who present with insufficient space and resultant crowding most often require treatment in the mesiodistal (MD) and buccolingual (BL) direction. Classification is categorized into the amount of overlap, as well as papilla height and shape (Table). Since papilla height discrepancy is slight in Class I and Class II case types, and papilla shape distortion is not visible, no adjunctive therapy is necessary. However, Class III case types frequently require adjunctive orthodontic and/or periodontal therapies and may require elective endodontics in borderline cases to correct functional and aesthetic deficiencies. Class IV case types cannot and should not be treated without orthodontic and periodontal consideration.

Clinical Procedures for Crowding

A 55-year-old male patient presented with moderate-to-severe misalignment of teeth #22(33) through #27(43), along with a preexisting porcelain-fused-to-metal (PFM) restoration on tooth #8(11) (Figures 1 and 2). While teeth #23(32) and #25(41) were positioned facially, teeth #24(31) and #26(42) were lingually retroclined and created an uneven overlapping appearance. The mandibular arch was evaluated in order to ensure development of proper incisal contours. Following impression capture, a stone cast was fabricated (Figure 3). Areas that required reduction were marked in blue, and red lines were drawn on the incisal edges to indicate the ideal restored arch position (form). The free gingival tissue height was also marked to ensure development of the correct gingival architecture.

One of the most significant problems when treating the insufficient (crowded) case type is creating natural-looking gingival architecture. The facially positioned teeth present a thin alveolar crest with relatively thin gingival tissue (that is generally positioned apically). It was easier and more predictable to move the soft tissues apically than to bring them towards a coronal direction. Conversely, if the teeth had been positioned too far lingually, as commonly found with an overgrowth of gingival tissue towards the coronal direction, distorted gingival symmetry would have been observed. In the majority of these cases, simple gingivectomy would be necessary in order to achieve correct gingival form.

The mesiodistal overlaps were marked with blue vertical lines to ensure proper reduction in order to allow subsequent expansion of the restored dental arch (Figure 4). A buccolingual overlap of approximately 2 mm was evident from one incisal edge to the other (Figure 5). A mesiodistal overlap of less than 1 mm was also evident. This borderline Class II/Class III case demonstrated some visible distortion in the free gingival height.

<table>
<thead>
<tr>
<th>Category</th>
<th>Amount of Overlap</th>
<th>Papilla Height Discrepancy</th>
<th>Papilla Shape Distortion</th>
<th>Adjunctive Therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>MD &lt; 1 mm</td>
<td>Symmetrical</td>
<td>Not Visible</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>BL &lt; 1 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class II</td>
<td>MD &lt; 1 mm - 2 mm</td>
<td>&lt; 1 mm</td>
<td>Not Visible</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>BL &lt; 1 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class III</td>
<td>MD &lt; 1 mm - 2 mm</td>
<td>1.5 mm - 2 mm</td>
<td>Moderate</td>
<td>Consider Periodontal, Orthodontic, and/or Endodontic</td>
</tr>
<tr>
<td></td>
<td>BL &lt; 1 mm - 2 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class IV</td>
<td>MD &lt; 2.5 mm</td>
<td>&gt; 2 mm</td>
<td>Severe</td>
<td>Recommended Orthodontic/Consider Periodontal</td>
</tr>
<tr>
<td></td>
<td>BL &lt; 2 mm</td>
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</tbody>
</table>
Removal of the mesial and distal interproximal areas of the labially positioned tooth was indicated in order to create sufficient space needed to shift the lingually positioned tooth facially.

It was critical for the clinicians to decide where to place the facial surface so that a pleasing arch form would be developed. Once the functional waxup was created, an accurate diagnostic waxup was used as the basis for the preparation guide. A red line was drawn on the incisal edge of tooth #23 to indicate the position of the ideal arch form (Figure 5).

Using a finishing bur, the laboratory technician created an arch-form preparation guide by preparing each tooth buccally and lingually on the stone model to develop an ideal arch form (Figure 6). This arch-form preparation was given to the clinician as a reference during the clinical tooth preparation phase. A mock-up was then created to allow visualization of the anticipated tooth form (Figure 7). Using condensation silicone putty, an incisal index of the mock-up was made (Figure 8). Pencil lines were drawn on the index to indicate proper spatial relationship as well as width of teeth at the incisal edge.

A depth bur was then used in the laboratory to reduce the labially positioned teeth according to the information provided by the incisal index (Figures 9 and 10). The labial index was used by the dentist as a reference guide during tooth reduction and preparation. This guide was also used to indicate the correct final position and help in visualizing the final dimensions of each tooth (Figure 11). Minimal preparation was required on the facial surface to ensure that the lost labial volume would be filled with the porcelain laminate veneer. In order to prevent development of a thick incisal surface, the incisal edge was trimmed lingually. Care was taken to avoid excess reduction and subsequent modification of the finishing line to maintain substantial support for the ceramic material.

Once the tooth preparation was completed, an impression was made and sent to the laboratory. A stone model of this impression was poured and checked against

Figure 9. The faciially positioned tooth were prepared on the stone model using the incisal index as a guide.

Figure 10. Incisal view of the completed laboratory preparation guide. Note the presence of suggested finishing-line placement.

Figure 11. Tooth preparation was initiated according to the predeter-
minal parameters communicated by the labial index.
the incisal index to verify the accuracy of the preparation (Figure 12). The incisal index was used in the laboratory to allow the technician to develop an optimal ceramic buildup (Figure 13). The restorations were fired and characterized as necessary, and the finished restorations were then sent to the dentist for definitive cementation. The definitive restorations were cemented using a composite resin adhesive and cement (Figures 14 and 15).

Conclusion

RSM is a predictable treatment for many aesthetic and functional dental problems. A classification of treatment guidelines is presented as a clinical means to recommend various treatment modalities to ensure aesthetic and restorative success.

The RSM case presented herein has replicated the treatment outcomes of orthodontic therapy through the use of aesthetic and restorative techniques. The benefits include correction of tooth shapes and dimensions that result in improved tooth proportions with an aesthetically pleasing appearance. The occlusal relationship has also been remedied to ensure a stable occlusion and proper masticatory function.

Acknowledgement

The authors mention their gratitude to Dr. Marc Lowenberg, New York, NY, for his contributions to the clinical case shown herein.

References

1. Restorative space management (RSM) alone can be predictably performed in:
   a. Only Class I case types.
   b. Only Class II case types.
   c. Both Class I and Class II case types.
   d. Neither Class I nor Class II case types.

2. RSM therapy alone can be predictably performed in type III and IV case types. RSM type IV cases can be treated as Class I or Class II postorthodontic treatment.
   a. The first statement is true, the second statement is false.
   b. The first statement is false, the second statement is true.
   c. Both statements are true.
   d. Both statements are false.

3. Class III case types should consider what type of adjunctive therapy?
   a. Periodontal.
   b. Orthodontics.
   c. Endodontic.
   d. All of the above.

4. Class IV case types always require:
   a. Orthodontic therapy.
   b. Periodontal therapy.
   c. Endodontic therapy.
   d. None of the above.

5. Adjunctive orthodontics is a predictable way to alter ____ soft tissue profiles.
   a. Midfacial.
   b. Interproximal.
   c. Both a and b.
   d. Neither a nor b.

6. RSM can be predictably accomplished without case planning. RSM can be predictably accomplished without a clinically applicable diagnostic waxup.
   a. The first statement is true, the second statement is false.
   b. The first statement is false, the second statement is true.
   c. Both statements are true.
   d. Both statements are false.

7. A diagnostic waxup with associated preparation guides is recommended in which case types?
   a. Class I and Class II.
   b. Class III and Class IV.
   c. Class I, Class II, and Class III.
   d. Class I, Class II, Class III, and Class IV.

8. This case type could require tooth mutilation, as well as significant periodontal therapy.
   a. Class I.
   b. Class II.
   c. Class III.
   d. Class IV.

9. Golden proportion is the ratio between:
   a. Central and lateral incisors.
   b. Canines and the first premolar.
   c. The first and second premolars.
   d. All of the above.

10. Tooth proportion is defined as:
    a. Width divided by length.
    b. Length divided by width.
    c. Width plus length.
    d. Length minus width.