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Criteria for the selection of restoration materials

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Selection of the appropriate material for dental restoration has become more and more difficult owing to the increasing variety of restoration materials. A decision flow chart is presented to guide the treatment team (dentist and dental technician) in the selection of the restoration material. This material selection is based on the available interocclusal space, esthetic aspects (eg, brightness value or translucency of the neighboring teeth), as well as clinical evidence extracted from survival rates. *(Quintessence Int 2014;45:723–730; originally published in Quintessence Zahntech 2013;39(4):462–470; doi: 10.3290/j.qi.a32509)*

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In recent years, the options for reconstructive treatment have increased with the introduction of innovative technologies (eg, CAD/CAM), the further development of existing materials, and the improvement of adhesive cementation. Thus, various all-ceramic materials may be a valuable treatment alternative to the existing gold standard of metal-ceramic restorations. All-ceramic materials exhibit similar light dynamics to natural teeth and thereby may offer esthetic benefit (Figs 1a and 1b). However, all-ceramic restorations are significantly weaker than metal-ceramic restorations, and their clinical success depends on the correct indication.

The success of a prosthodontic treatment, especially when a single tooth has to be restored, is based on the "correct" selection of the restoration material. However, the material selection is influenced by subjective factors, such as the patient's desire for metal-free restorations, the dentist's expectations for maximal stability, and the dental technician's experience with a preferred material. These subjective factors may be detrimental, and lead to an "incorrect" material selection.

Each clinical situation has to be analyzed systematically by means of a decision tree to allow selection of the most appropriate restoration material.

Long-term studies have shown similar results for full- and metal-ceramic crowns regarding stability and long-term success.[1] Consequently, the choice of the material for a single tooth restoration is mainly based on four esthetic factors[2,3]:

- the translucency of the neighboring teeth
- the brightness value of the neighboring teeth
- the available space in the buccal area
- the degree of discoloration of the abutment tooth.

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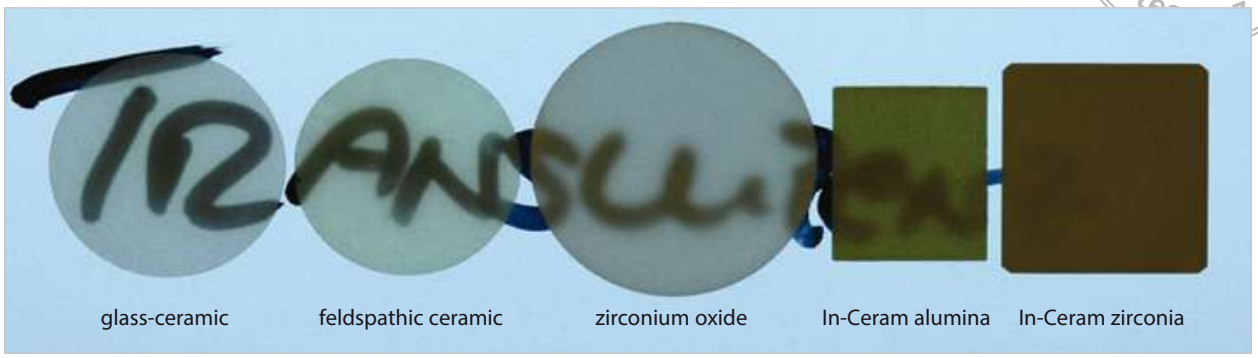

Fig 1a Translucency of 0.5-mm-thick plates of different materials: glass-ceramic, feldspathic ceramic, zirconium oxide, In-Ceram alumina, and In-Ceram zirconia.

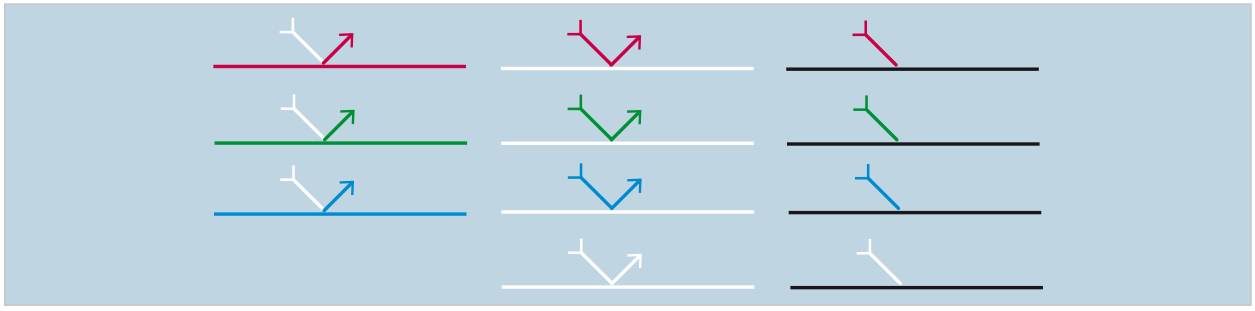

Fig 1b Schematic drawing explaining the reflection of light depending on different framework materials.

However, for multi-unit fixed dental prostheses (FDPs) additional factors have to be considered for the choice of material. According to the systematic review of Pjetursson et al,[1] the long-term results of tooth-supported full- and metal-ceramic FDPs were evaluated.[4] Both systematic reviews calculated the incidence of biological and technical complications.

The five-year survival rates for metal-ceramic crowns were 95.6%, for reinforced glass-ceramic crowns (eg, Empress; Ivoclar Vivadent) 95.4%, and for glass-infiltrated alumina crowns (eg, In-Ceram; VITA) 94.5%. There were no statistically significant differences between groups. Consequently, both full-ceramic as well as metal-ceramic crowns may be indicated for single tooth restorations. In contrast, metal-ceramic FDPs showed a survival rate of 94.4% after 5 years, while FDPs with ceramic frameworks had a significantly lower survival rate of 89.6%. When the literature search for the systematic review was performed, only a few studies on zirconia were published. Nevertheless, the results could already reveal an interesting trend at that

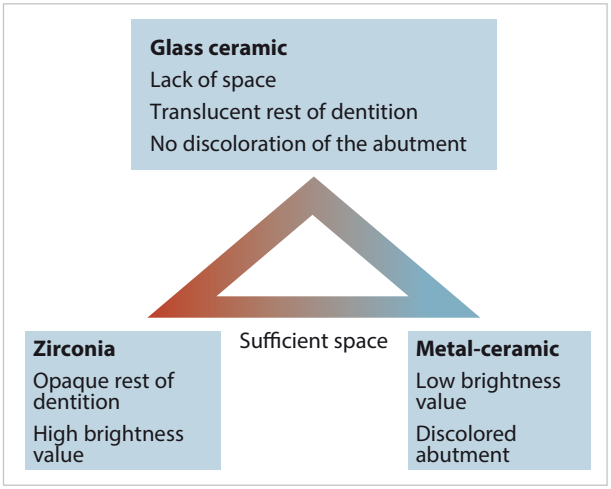

Fig 2 Decision matrix to evaluate the most appropriate restoration material.

time. The failures of metal-ceramic FDPs occurred due to biological and technical complications, while the failures of all-ceramic FDPs manufactured from weaker ceramics, eg reinforced glass-ceramics, were due to fractures of the framework. In contrast, FDPs with zirconia frameworks showed similar technical and biological

Fig 3a Highly translucent left maxillary central incisor serves as reference to restore missing right maxillary central incisor.

Fig 3b Right maxillary central incisor was restored with a glass-ceramic crown.

Fig 3c Highly opaque right maxillary central incisor serves as reference to restore missing left maxillary central incisor.

Fig 3d Left maxillary central incisor was restored with a veneered zirconia crown.

complication rates when compared to metal-ceramic FDPs. However, a higher rate of ceramic fractures (chipping) was reported.

The material selection of single tooth restorations mainly depends on esthetic factors, while the indications for all-ceramic FDPs are more complex and are influenced by mechanical aspects such as the stability and the length of the edentulous gap.

All these factors interact closely with one another, as shown in Fig 2.

CLINICAL AND TECHNICAL FACTORS INFLUENCING THE MATERIAL SELECTION

Translucency of the neighboring teeth

The first step in the systematic evaluation of the material selection is the assessment of light transmission in the reference teeth. The amount of translucency or opacity in the reference teeth has to be defined (see Fig 2). The first assessment is therefore based on visual criteria.

If the teeth show a high translucency (high amount of light transmission), glass-ceramic is favored as the restoration material of choice. It ensures maximum light flux and therefore crowns exhibit a translucent effect.[5-7] Later, this effect may be amplified by the use translucent veneering ceramics (Figs 3a and 3b).

In contrast, a deeply opaque reference tooth (with low amount of light transmission) is often associated with a monochrome color effect. Thus zirconia may be recommended as core material due to its material properties, the uniform tooth-colored appearance, and in general the reduced translucency.[4] The use of highly translucent veneering ceramics in combination with opaque zirconia cores means a predictable highly esthetic outcome may be achieved (Figs 3c and 3d).[8]

Brightness value of the neighboring teeth

The second step in the evaluation of the material selection is the assessment of the brightness value of the reference teeth. Thus, the second assessment also focuses on visual criteria.

Fig 4a Left maxillary central incisor with a high value of brightness serves as reference to restore missing right maxillary central incisor.

Fig 4b Right maxillary central incisor was restored with a veneered zirconia crown.

Fig 4c Right maxillary central incisor with a medium value of brightness and a highly chromatic value serves as reference to restore missing left maxillary central incisor.

Fig 4d Left maxillary central incisor was restored with a glass-ceramic crown.

Fig 4e Left maxillary central incisor with a low value of brightness and a high amount of gray color serves as reference to restore missing right maxillary central incisor.

Fig 4f Right maxillary central incisor was restored with a porcelain-fused-to-metal crown.

Basically, the brightness value can be subdivided into the color "white", the color with the highest brightness value, and the color "black", the color with the lowest brightness value. By transferring this information to the clinical setting the color "white" represents a very bright and opaque tooth. In contrast, the color "black" is associated with a very dark, gray, and translucent tooth (see Fig 2).

When the framework material is selected based on the brightness value of the reference teeth, the most predictable result may be achieved if "white" teeth are restored with zirconia crowns (Figs 4a and 4b) and "black" teeth, with a more gray and translucent appearance, are restored with glass-ceramic (Figs 4c and 4d) or metal-ceramic crowns (Figs 4e and 4f).

Space in the buccal area

The third step in the evaluation of the material selection is based on technical aspects and includes the assessment of the available buccal space.

Fig 5a Minimally invasive tooth preparation of fractured right maxillary central incisor.

Fig 5b Minimal buccal reduction.

Fig 5c Glass-ceramic restoration of right maxillary central incisor after adhesive cementation.

Fig 5d Minimally invasive preparation of mandibular right canine to left central incisor, and left canine, with Odontogenesis imperfecta.

Fig 5e Circumferential preparation with a reduction of tooth substance less than 0.8 mm.

Fig 5f 360-degree veneers based on glass-ceramic in place (mandibular right canine to left central incisor, and left canine).

Fig 5g Classic crown preparation, right maxillary central incisor.

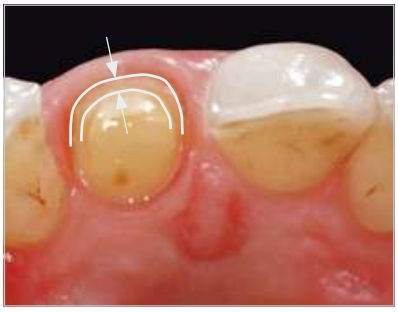

Fig 5h Circumferential preparation with a reduction of tooth substance of approx. 1 mm.

Fig 5i Veneered zirconia crown, right maxillary central incisor (courtesy of Walter Gebhard, Zürich).

Fig 5j Invasive crown preparation of nonvital abutment tooth, right maxillary central incisor.

Fig 5k Circumferential preparation with a reduction of tooth substance of 1.5 mm.

Fig 5l Porcelain-fused-to-metal crown, right maxillary central incisor (courtesy of Belinda Sapina, ZZM Zürich).

Fig 6a Tooth-colored homogenous abutment tooth: no need to mask. Glass-ceramic allows the ideal transmission of light.

Fig 6b Slightly discolored abutment tooth, minimal need to mask. Similarly, glass-ceramic allows the ideal transmission of light.

Fig 6c Moderately to severely discolored abutment tooth with slight grayish discoloration of gingival margin: minimal need to mask. To be restored with slightly increased value of opacity in the glass-ceramic or a translucent zirconia core.

Fig 6d Severely discolored abutment tooth with gold build-up and apparent discoloration of marginal gingiva: need to mask. To be restored with a zirconia core with minimal thickness of 0.4 mm.

Fig 6e Severely discolored abutment tooth with gold build-up and obvious discoloration of marginal gingiva: need to mask. To be restored with a zirconia core with minimal thickness of 0.6 mm or a classic porcelain-fused-to-metal crown.

Fig 6f Extremely discolored abutment tooth with dark gold build-up and strong discoloration of marginal gingiva: maximal need to mask. To be restored with a classic porcelain-fused-to-metal-crown to achieve predictable esthetic outcome.

The available space is divided into "minimal" or "sufficient" (see Fig 2). Considering the clinical and technical requirements of restoration materials, such as the opacity level or the minimum wall thickness, the material of choice in minimally or less-invasive areas (with an available space of ≤ 1 mm) is exclusively glass-ceramic. Glass-ceramic is the only material that allows unimpeded light transmission to the supporting tooth surface (Figs 5a to 5f). If the available space is greater than 1.2 mm, zirconia may be a valuable alternative to glass ceramics (Figs 5g to 5i). In clinical situations with an available space of ≥ 1.5 mm, the question of the correct framework material loses its relevance (Figs 5j to 5l).

Degree of discoloration of the abutment tooth

The fourth and final step in the evaluation of the material selection is also based on technical aspects, and involves the assessment of the abutment tooth color and its effect on the reconstruction material. The abutment tooth may be subdivided into three categories:

- uncolored with a homogenous appearance
- slightly to moderately discolored
- severely discolored, with metal build-ups (see Fig 2).[9]

The choice of material is critical in the latter group. On one hand, the dark color has to be masked. On the other hand, the dark color of the abutment tooth and its roots may negatively affect the appearance of the surrounding gingiva.

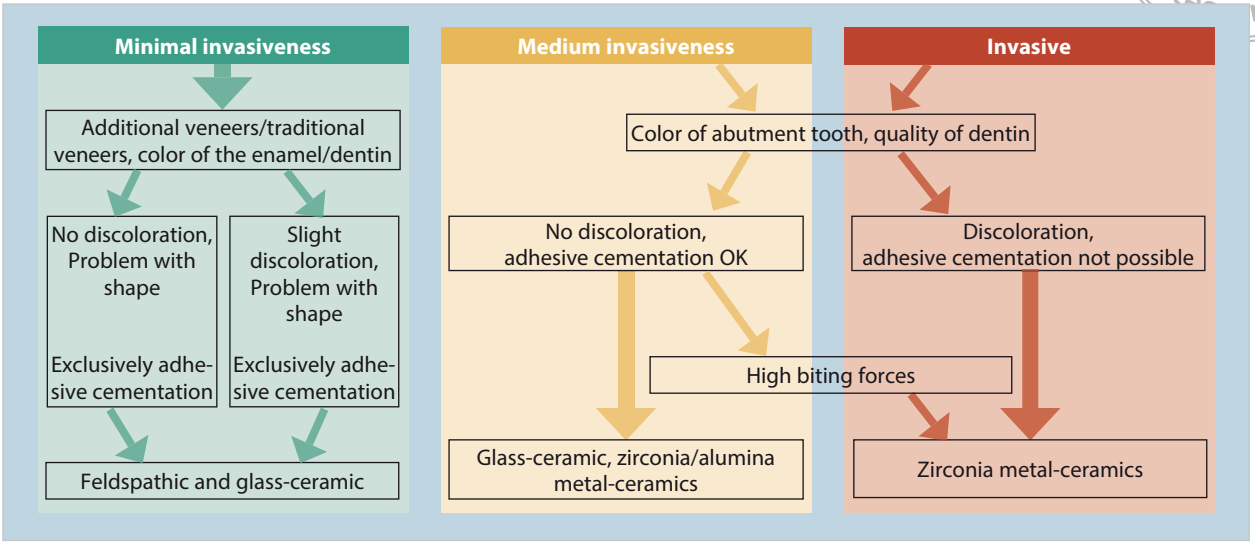

Fig 7a Decision matrix for single restorations determining the invasiveness of the treatment based on the material selection.

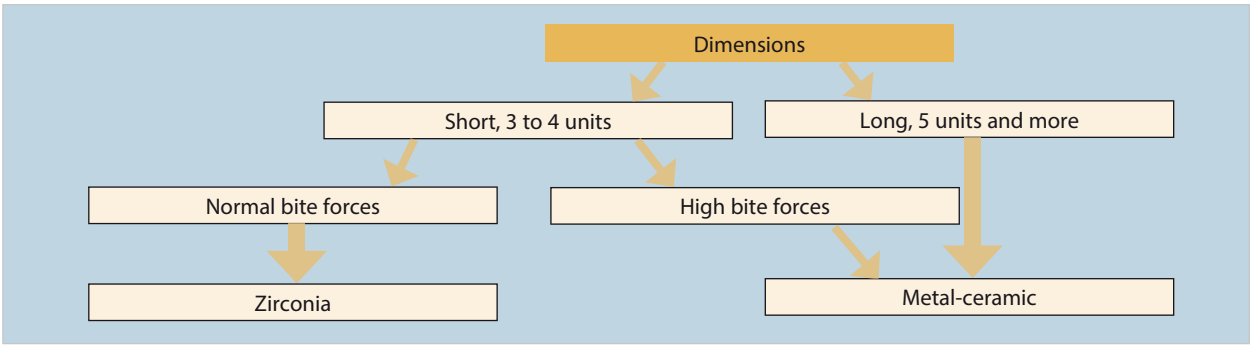

Fig 7b Decision matrix for FDPs determining the material selection based on the length of the span.

Since all-ceramic materials including zirconia allow the transmission of light at a material-specific wall thickness,[4] it is recommended to use glass-ceramic as framework material only for an uncolored or slightly discolored abutment tooth (Figs 6a to 6c).

When restoring moderately to severely discolored abutment teeth, the material selection also depends on the available space. If, for example, zirconia was selected as material of choice based on the brightness value and the translucency of the reference teeth (Fig 6d), a higher minimum thickness for the core material has to be respected for moderately to severely discolored abutment teeth. In clinical situations with severely discolored abutment teeth an esthetic outcome may only be achieved by the use of a high-noble alloy as framework material. Metal-ceramic restorations with a core thickness of 0.3 mm may offer sufficient firing stability and completely mask the underlying staining (Figs 6e and 6f).

DISCUSSION

The selection of materials for single-tooth crowns depends primarily on esthetic factors such as the color of the abutment tooth and the neighboring teeth, as well as their brightness value and translucency. The breakdown of these factors can be easily achieved and categorized (Fig 7a). However, with FDPs included in the spectrum, the length of the edentulous space is the most decisive factor for the selection of the reconstruction material (Fig 7b). Regarding the treatment with FDPs, short (three to four units) and long (five and more

units) prostheses need to be differentiated. The longer the edentulous span, the more stable the framework required. For this reason, at present zirconia is the only all-ceramic alternative to metal frameworks. Recent results of a clinical study with an observation period of 10 years evaluating zirconia-based FDPs indicated that the risk for technical complications significantly increased with the length of the span.[10] Accordingly, the risk for chipping of the veneering ceramic increases significantly with the length of the span.[10] These results suggest that with increasing edentulous gap size, a FDP with a metal framework should be preferred.

CONCLUSION

In the clinical setting all these factors are closely related. Visual requirements and technical possibilities have to be balanced in each clinical situation. Finally, the material fulfilling most of the factors is selected as the material of choice. Thus, the material selection can be compared with a field of tension in which the change of one parameter may affect all other parameters. Currently, no universally applicable material is available.

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