CONTEMPORARY MAXILLARY IMPLANT-SUPPORTED FULL-ARCH RESTORATIONS COMBINING ESTHETICS AND PASSIVE FIT

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Since the introduction of osseointegrated implants by Branemark,[1,2] the focus of implant-supported restorations has been implant survival and proper function. Initially, the esthetic result was not of primary importance. Recently, however, increasing patient demands and technological advances have led to the development of new techniques to fabricate implant-supported full-arch restorations, especially in the maxilla. These techniques offer more esthetically pleasing prostheses that achieve passive fit and can be repaired within the veneering porcelain if needed.

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IMPLANT-SUPPORTED FULL-ARCH RESTORATIONS: PROBLEMS

Passive Fit

A passively fitting framework has been described in the literature as both necessary[3] and difficult to achieve.[4–6] Implant prostheses do not exhibit the same degree of movement compared to the periodontal ligament found around natural teeth[7]; therefore, the techniques employed in conventional dentistry do not work as predictably in implant dentistry. Inaccuracies in implant restorations are the result of a number of factors, including inherent machining tolerances of components,[8] distortion of impression material,[9–12] setting expansion of dental stone,[13,14] expansion and contraction of alloy and wax,[15] expansion of investment material,[16] and distortion of the framework during heat treatment and porcelain application.[17] In addition, misfit is magnified by assembling the restoration on a copy of the patient's mouth (the master cast) rather than on the patient's mouth itself.

Traditionally, these deficiencies have been overcome by using repeated intraoral try-ins and by cutting and soldering the framework prior to veneer application, but studies have shown that soldering does not necessarily improve the fit of implant-supported restorations.[18,19] Further, postsoldering is often technically impossible due to excessive frame dimensions in moderately to severely resorbed cases. Cemented restorations have thus become very popular with clinicians, who use the cement space to increase passive fit compared to screw-retained restorations.[20–22]

Esthetics

Fabricating esthetically pleasing implant-supported full-arch restorations is a difficult task, especially in the maxilla. The loss of hard and soft tissues compromises the esthetic result. Teeth become long and narrow due to the resorption of the residual ridge. In the gingival area, teeth are often curved palatally due to bone loss patterns that reduce bone height and circumference.[23–25] Technically, the sheer magnitude of building a full-arch restoration makes it impossible to achieve the attention to detail that is typically necessary to fabricate a single-tooth restoration. Managing internal and external characterization becomes impossible. Building the crowns in succession will lead to more firings than usual, resulting in large porcelain restorations with a nonvital appearance. Thus, full-arch porcelain restorations are often doomed esthetically before they even begin.

Long-term service and the potential benefits of retrievability are additional factors unique to implant-supported restorations. If any veneering of the restorations fails, the entire restoration is at risk. Once the restoration has been inserted for even a short period of time, it is impossible to repair porcelain fractures by adding porcelain in the oven. The other option is to try to repair the fracture intraorally or in the laboratory with a composite material. Although this option has fewer risks, it is at best a compromise to the overall quality, integrity, longevity, and esthetics of the restoration.

IMPLANT-SUPPORTED FULL-ARCH RESTORATIONS: SOLUTIONS

Altered Framework Design

An altered framework design was developed to address the implant-specific concerns mentioned above: passive fit, artistic freedom, form, function, retrievability, and ability to repair potential porcelain fractures.[26] The concept is based on luting copings intraorally into the framework, thus predictably achieving a passive fit of the cast restoration. In addition, the design principles of building single crowns for improved esthetic results as well as an option for predictable repair were incorporated.

Treatment planning for an implant-supported restoration requires the determination of the ideal vertical dimension, arch form, and occlusal plane of the final prosthesis prior to implant placement.[27] These prosthetic parameters are verified clinically through the evaluation of fixed provisional restorations supported by teeth that will be extracted after the healing phase of the implants or by a complete denture setup in totally edentulous patients. In addition to the established requirements prior to surgical implant placement,[28] the number and location of implants necessary to support the planned restoration are determined. A surgical template incorporating these prosthetic parameters is used to optimize implant placement. While the original protocol used surgical templates derived from common prosthetic principles, today's patient can benefit from computer-aided design/computer-assisted manufacture (CAD/CAM)-generated surgical templates that allow a minimally invasive procedure[29–31] (NobelGuide, Nobel Biocare, Göteburg, Sweden) and immediate function.[29,32,33] Upon soft tissue maturation, a master cast is fabricated. Provisional restorations that have been carefully adjusted to

Fig 1 Implant-supported provisional prosthesis used to assess esthetic and phonetic parameters.

Fig 2 The master cast is mounted with a facebow and cross mounted with the maxillary and mandibular arches. While the provisional prosthesis is on the master cast, a silicon index covering the entire restoration is fabricated.

Fig 3 Titanium abutments are milled to a common two-degree taper. A coping is waxed and cast onto each of these abutments.

Figs 4a and 4b The coping exhibits an intimate fit to the underlying abutment. Prior to fabrication of the suprastructure, die spacer is applied to the axial wall of the copings. The thickness of the die spacer increases with more distal locations of the abutment.


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2


3


4a


4b

fulfill the prosthetic, phonetic, and esthetic needs of the patient (Fig 1) are necessary because of the complexity and expense associated with a full-arch ceramic restoration. The provisional restoration is used to mount the master cast with standard prosthetic techniques (Fig 2).

Modifiable prefabricated titanium abutments are selected according to the implant angulation and size of the restoration. The location for the finish line is determined based on the esthetic needs and implant location. In the esthetic zone, the abutments are prepared for a 1-mm subgingival finishing line. In the non-esthetic zone, an equi- or supragingival finishing line can be selected. All abutments are prepared to rest within a vacuform template of the diagnostic waxup, milled with a 2-degree taper on a milling machine, and then polished. In addition, grooves or flat areas are incorporated into the abutments to facilitate their transfer to the oral cavity and ensure the exact repositioning of the abutments after transfer.

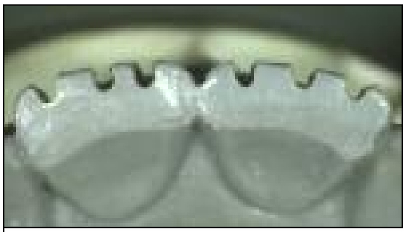
A coping is fabricated for each milled abutment from wax or from composite material. The copings are finished to a maximum thickness of 0.3 mm. Special care should be taken to ensure a proper marginal seal. The copings are then invested, cast in gold, and fitted to their respective abutments (Fig 3). A second coping is fabricated from light-cured resin over the cast gold coping. These copings act as spacer copings and are finished to a thickness of 0.2 mm in the anterior region and 0.55 mm in the posterior region (Fig 4). Each spacer coping extends toward the gold coping margin but terminates at the internal line angle of the gold coping's axial wall/shoulder junction. This light-cured spacer is polished but not cast in gold. The spacers are then placed onto their respective cast gold copings, each of which is seated on its milled implant abutment.

Subsequently, a full-arch waxup is fabricated over the gold copings and resin spacers. For frameworks that are to be fabricated with CAD/CAM technology, acrylic resins or composite resins are the materials of choice. Prior to waxing, a separating medium is applied to the acrylic spacers. The waxup reestablishes the ideal tooth length and position and tissue height. Ideally, a silicone index of the provisional restoration on the master

Fig 5 The silicon index of the provisional restoration, seated on the master cast, is split and fitted with vent holes, allowing wax or acrylic pattern resin to be injected.

Fig 6 The provisional restoration, which was evaluated intraorally by the patient, is duplicated in either wax or acrylic resin on the master cast to ensure the success of the definitive restoration.

Fig 7 Deficiencies in the contours and details are corrected, and vent holes are eliminated. The prosthetic parameters that were established intraorally with the provisional restoration have been transferred successfully to the master cast.



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8b

8c

Figs 8a to 8c The full contour waxup is prepared. The tooth portion of the restoration is effectively a preparation of the individual tooth, providing adequate reduction, resistance, and retention. Care should be taken to mimic the desired gingival height and contour. Once all teeth have been prepared to receive a crown, the tissue portion of the framework is reduced. The amount and form of preparation depends on the veneering material.

cast was obtained during the mounting appointment (Figs 5 to 7). Alternatively, a vacuform or other index of the verified provisional prosthesis can be secured to the cast and filled with wax. This waxup should be executed precisely since it determines the final size, shape, and position of the prosthesis, and is verified by cross mounting of the opposing dentition with the provisional restoration and waxup.

Each tooth is prepared in wax as if it were a real tooth to establish the ideal preparation for each individual crown. All preparations extend slightly into the tissue waxup (Fig 8). After preparation of all teeth, the tissue waxup is also cut back. The tissue is reduced until only a minimal framework is left. The framework is recontoured around the implant abutments and measures approximately 0.3 mm in thickness around the abutments. The wax framework is adapted to the margin of each cast gold coping. Subsequently, the individual tooth preparations are redefined.

The framework can be cast as a single piece (Fig 9) or in multiple segments. Once the waxup is removed from the cast, a pair of tweezers is used to remove each cast gold coping and acrylic spacer from the inside of the frame (Fig 10).

The framework is cast in alloy, onto which porcelain can be baked. After casting, the framework is checked on the master cast (Fig 11). If the full arch was cast in one piece, the acrylic spacers should be removed from the gold copings before seating them on the master cast. The gold copings are placed on the proper abutments, and the full-arch casting is placed over the assembly on the master cast. The casting should fit loosely over each abutment and coping. If an adequate fit is not achieved, the inside of the framework should be adjusted until a passive fit is evident.

Fig 9 The framework is sprued on the master cast. This can be done in a single piece or in sections. Alternatively, a screw-retained framework can be scanned for CAD/CAM production.

Fig 10 Prior to investing the framework, the individual copings are removed.

Fig 11 When seated on the master cast, the framework should exhibit passive, loose fit when the copings are seated on the appropriate abutments,with the die spacer removed.

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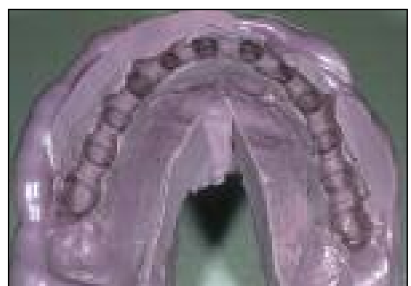

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Fig 12 The tissue-receiving portion of the framework is waxed up to block out the undercuts and develop the emergence profile around the crowns.

Fig 13 Full-arch impression of the framework seated on the master cast.

Fig 14 Individual dies for all crowns are fabricated using the traditional methods. Copings can be fabricated using traditional or CAD/CAM techniques.

Fig 15 Individual copings seated on the master cast.

Once the fit has been evaluated, the framework is finished and prepared to receive porcelain in the tissue areas apical to the crown margins. The tissue portion is waxed back onto the framework to achieve the ideal contours. The waxed tissue will serve two purposes: *(1)* it will aid in the proper contouring of the crown buildups, and *(2)* it will block out potential undercuts in the metal framework when an impression of the framework seated on the master cast is taken (Fig 12). The impression, taken with standard impression material for fixed partial dentures (Fig 13), is poured in improved die stone. Individual dies of each preparation are then prepared (Fig 14).

From this point on, the fabrication of the definitive restoration is comparable to traditional restorations. A full arch of individual copings is fabricated to fit the stone dies. Each coping is opaqued in its appropriate shade. Porcelain margin material is applied circumferentially to each coping (360 degrees), even though the metal copings have not been prepared to receive a conventional porcelain margin. It is a decisive advantage to use these materials in the marginal area to optimize the esthetic result. The opaqued copings with the porcelain margins are then returned back to the original metal framework (Fig 15).

16d

Fig 16 Individual crowns are fabricated for the entire arch. Note the artistic detail and vibrancy of the porcelain.

Figs 17a to 17c Various pink porcelain shades are applied to the buildup to mimic the natural tissue color and overall gingival appearance.

17a

17b

17c

At this stage, each coping receives its porcelain buildup. This allows the crowns to be fabricated individually, thus maintaining maximum artistic freedom (Fig 16). Once all crowns are fired and contoured, they are ready to be glazed. Prior to glazing, it is recommended to proceed with at least one tissue-porcelain firing. For this purpose, the crowns are removed from the framework and the wax simulating the tissue is boiled off. The tissue portion of the frame is then opaqued. A ceramic separating pen is used to insulate the gingival areas of the crowns so that the gingival porcelain will not stick to the crowns upon removal. The tissue porcelains are then applied from the margins of the framework approximately 0.5 mm above the height of each crown margin (Fig 17). Once all tissue porcelain is applied and contours are evaluated, each crown is lifted off the framework without disturbing the surrounding tissue buildup. The frame is then placed on a tray and fired in the porcelain oven.

After firing, the crowns are placed back on the framework, and the process of applying tissue porcelain is repeated a second time to finalize the tissue contours. In some cases, a third firing may be necessary depending on the amount of porcelain shrinkage. The pre-glazed crowns are placed onto the tissue frame. All crown and tissue contours are then evaluated for proper shape and emergence profile, recontoured if necessary, glazed, and polished with pumice. Each crown is returned to the tissue frame to evaluate the contours and the size of the gap between the gingival crown contour and the adjacent tissue porcelain. If this space is too large, corrections can be carried out using low-fusing porcelain to minimize the gap. If an anatomic buildup of the tissue porcelain was executed, little or no grinding will be necessary. A low-temperature glaze firing of the tissue porcelain is carried out. Polishing is then carried out with a rubber wheel and pumice. Now, the tissue framework is ready to receive the individual ceramic restorations (Fig 18).

Each tooth preparation is in metal, as is the inside of each crown. The remaining exposed metal preparations and the inside of the crowns are silicoated to facilitate bonding between the framework and the crowns. The individual crowns are luted to the framework using an appropriate resin-based luting agent (Panavia TC, Panavia, Japan).

Figs 18a and 18b Prior to crown cementation, the application of porcelain to simulate the gingival tissues is completed. For screw-retained restorations, a decision must be made by the restorative dentist whether the screw access holes will be extended through the crowns in the laboratory or if the framework will first be seated intraorally.

18a

18b

19a

19b

19c

Figs 19a to 19c Full-arch porcelain restoration after cementation of individual crowns to the framework. This approach allows complete control of the most important esthetic and functional parameters.

The luting agent will flow into the gap between the tissue, porcelain, and crowns, and any excess should be removed before the curing is completed.

Once the luting agent is set, the inhibitor is removed and excess material is trimmed away. This process is repeated until all crowns are luted to the framework. The composite margin at the crown-tissue interface should be so small that it is clinically irrelevant. Using appropriate luting agents will enhance the illusion that the crowns are growing naturally from the ceramic tissue. All composite margins around the individual crowns are then polished (Fig 19).

Passive fit of the completed restoration is achieved by assembling it directly in the patient's mouth as opposed to on the master cast. The milled abutments are seated on their respective implants, oriented to coincide with the master cast, and tightened to the manufacturer's recom-

Fig 20 After cementation of the copings into the framework intraorally, the prosthesis is removed to facilitate cement removal. This close-up photograph reveals the minimal cementation line, representing the total distortion from impression taking to delivery of the prosthesis.

Fig 21 Full-arch porcelain restoration seated in the mouth.

mended torque. The gold copings are transferred to the mouth. The framework is seated over the abutment-coping assembly, and complete and passive fit is verified. If the framework does not seat completely, the interfering area is identified and adjusted accordingly. Subsequently, the internal aspects of the tissue framework containing the implant abutments and external aspect of the gold copings are silicoated and silanated. Three copings—one anterior coping and the two distal copings—that form a broad-based triangle are identified for the first luting cycle. The corresponding internal housings within the framework are filled with the luting agent (Twin Lock, Hereaus Kulzer, Irvine, California) and placed intraorally. The prosthesis is completely seated using finger pressure, and excess luting agent is removed with a brush and an explorer. Adequate fit of the framework over the gold copings and implant abutments is verified before a curing light is used to achieve initial setting. After 10 minutes, the dual-cure resin cement should be completely cured, and the framework is removed from the patient's mouth, including the three gold copings that now are an integral part of the framework. Excess cement is removed in the laboratory, and the luting process is repeated multiple times, incorporating two to four copings at any one time until all copings have been luted into the framework (Fig 20).

The result is a prosthesis with a totally passive fit because the components were assembled intraorally. The internal adaptation of each cast coping fits intimately with its implant abutment, assuring excellent marginal adaptation and coping retention. The acrylic spacers, which were placed between each coping and the framework during the initial wax-up and soldering procedures, compensate for any discrepancies in the accuracy of the master cast and subsequent casting and porcelain applications **[Au: sentence correct as edited?]**. Luting these copings intraorally results in a totally passive framework with maximum retention. The prosthesis is cemented with temporary cement after the abutment screw access has been sealed. It can be retrieved at any time if necessary (Fig 21).

The resulting prosthesis satisfies the original criteria: an implant-supported full-arch restoration with a completely passive fit that allows maximum artistic freedom while reestablishing the harmony and proportions between the teeth and supporting structures (Figs 22 and 23).

If fracture of a porcelain crown is observed (Fig 24), it can be handled as if it were a single-tooth restoration. The crown is cut off the framework intraorally, the site is re-prepared, and an impression is taken. Then, a new coping and crown can be fabricated, tried in, and luted to the framework (Figs 25 and 26). A conventional provisional restoration can be fabricated for the prepared abutment during the fabrication of the new ceramic crown.


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22b


22c


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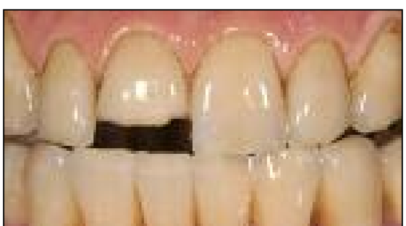
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25a


25b


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Figs 22a to 22c Final result. Note the duplication of the tooth position, height and form of the gingival contours, and lip support compared to the provisional restoration (see Fig 1).

Fig 23 The fully assembled framework prior to insertion. Note the artistic coloration and attention to detail of the teeth and soft tissues.

Fig 24 Thirteen years after insertion, the patient presented with a fractured right central incisor.

Figs 25a and 25b Without removing the prosthesis, the crown is cut off and impressions are taken for a new crown.

Fig 26 A new crown is cemented intraorally, thus repairing an otherwise catastrophic porcelain fracture quickly and predictably.

Computerized Treatment Planning and Implant Placement

The outcome of the prosthetic reconstruction is greatly improved by the use of computerized treatment planning[30,34,35](three-dimensional computerized tomography scan) and implant placement[32,36] (NobelGuide). The implants can be placed in the most favorable positions, and the surgical procedure can be carried out faster, less invasively, and more precisely.[34] Adequate transmucosal exit points, coronal-apical depth, mesiodistal spacing, and implant angulations can be predetermined and transferred exactly to the surgical field. This ensures that the definitive prosthetic reconstruction will be executed to the highest standards, with minimal interferences from screw holes, adequate embrasures, and avoidance of implants when they would interfere with the esthetic emergence profiles and adequate anteroposterior spread.[32] Prefabricated fixed prostheses, produced from the surgical template, can be inserted immediately after implant placement.[36–38] During the past decade, the ideal number of implants used to restore a full arch has decreased steadily. Today, four to six implants seem adequate to predictably support an entire arch.[37] This reduced number not only allows for a decreased treatment time and cost,[39,40] but also allows patients to receive a fixed implant-supported dentition that is comparable in cost to a bar-retained overdenture on 4 implants, with less long-term maintenance.

CAD/CAM Framework Design

CAD/CAM technology has revolutionized dentistry. One of the most beneficial improvements was the development of techniques allowing for the fabrication of a passively fitting, screw-retained framework on a master cast.[41–43] As discussed above, large metal frameworks that needed to be cast often did not fit adequately.[17] For frameworks receiving porcelain veneering materials, additional firings induced more distortion of the framework, often resulting in a clinically unacceptable prosthesis.

Thus, techniques were developed to circumvent most of the issues associated with elaborate laboratory and clinical procedures.[39] With the introduction of CAD/CAM technology, it is now possible to have a precise, perfectly fitting framework milled from one piece of titanium or zirconium oxide.[44–46] It is important to realize that this passive fit is dependent upon an accurate master cast, and that any inaccuracies during master cast fabrication are incorporated into the framework.

Today, the practitioner has two choices when it comes to framework substrate: titanium or zirconium oxide. A titanium framework is used most often as a supporting structure for prefabricated teeth that are processed onto the framework or as a substructure to receive individual, cemented ceramic crowns.[47] A zirconium oxide framework is the framework of choice for an all-ceramic restoration, when the porcelain is either applied directly to the zirconium framework for a direct buildup or when individual crowns are fabricated over the framework and either pressed or cemented onto it.

The choice of framework material is based on esthetic needs of the patient, financial considerations, and technical specifications of the materials, such as length of cantilevers and framework-connector dimensions.

Basic Implant-Supported Full-Arch Restorations

A CAD/CAM-generated titanium framework (Pocera Implant Bridge Titanium, Nobel Biocare) supporting prefabricated composite or acrylic resin teeth and veneered with acrylic resin is the most proven and cost-effective way to restore full-arch implant cases.[40] The commercially pure titanium grade 2 framework is milled from a single block of titanium, duplicating a resin framework that is essentially fabricated according to the principles discussed above. The framework needs to be designed in such a way that it maintains adequate height and width of the titanium for strength and shows adequate retention and resistance to support the veneering materials. Such frameworks exhibit excellent fit[44] and provide long-term satisfactory service.[40] With adequate planning and execution, the orofacial width can be maintained at an acceptable minimum even when the resorption of the residual ridge has progressed.

Advanced Implant-Supported Full-Arch Restorations

Some patients desire a more esthetic restoration using customized, hand-made porcelain crowns

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Fig 27 "All-on-Four" implant-supported restoration with individual all-ceramic restorations. (Ceramist: Dr Dario Adolfi).

Fig 28 The final restoration is an exact copy of the provisional restoration.

Fig 29 Final smile view.

Fig 30 Acrylic resin framework prior to scanning and CAD/CAM production. The preparations for individual crowns are inspected for sufficient facial clearance with a silicone key. (Ceramist: Dr Dario Adolfi.)

Fig 31 The acrylic resin framework is checked for sufficient interarch clearance on the articulator.

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rather than prefabricated teeth. To satisfy this demand, the altered framework design,[26] incorporating individual single crowns onto a framework, has been modified to provide both passive fit and superior esthetics (Figs 27 to 29).[47] A screw-retained, milled titanium framework (Procera Implant Bridge Titanium) is used to support the crowns and tissue portion. The choice of veneering material for the tissue portion consists of either acrylic resin or composite materials. Should any changes in residual ridge morphology occur during the lifetime of the restoration, it can be easily adjusted by adapting the pontic area to the new clinical situation.

The technical aspects are similar to the altered framework design. After impression, facebow, and cross-mounting procedures, a provisional restoration is used as the guide to fabricate an acrylic or composite resin framework (Figs 30 and 31) with


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Fig 32 The milled titanium prosthesis is returned to the laboratory after production.

Figs 33 and 34 The crown preparations are opaqued, the gingival contours are reestablished, and undercuts are eliminated.

Figs 35 and 36 Individually fabricated crowns on the framework prior to cementation and tissue application.


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individual tooth preparations for each single crown. The framework is prepared for CAD/CAM procedures and returned to the laboratory (Fig 32). Individual all-ceramic copings (Procera, Nobel Biocare) are fabricated using zirconium oxide (Figs 33 to 36) and veneered with the appropriate porcelain system (NobelRondo, Nobel Biocare). If the restoration is designed as a fully retrievable prosthesis, access holes to the underlying screw channel are incorporated into the crowns after cementation (Fig 37). Once all tooth portions of the prosthesis are finished, attention should be directed toward the tissue-simulating areas. These can either be processed with acylic resin materials or built up in composite resin. The usual guidelines for designing the ridge-prosthesis contact areas apply: ovate pontic design in edentulous areas, interproximal access for proximal brushes (Fig 38), and high polishing or glazing. Upon completion, the prosthesis is ready for delivery (Fig 39).

Fig 37 Screw access holes are incorporated into all crowns for full retrievability.

Figs 38a to 38c For ideal implant placement in maxillary full-arch restorations, no implants should be placed in the incisor region. Ovate pontic design should be used in edentulous areas to provide adequate space for interproximal brushes.

Fig 39 Intraoral view of the definitive prosthesis.

Fig 40 Maxillary and mandibular provisional restorations. Note that no implants are placed in the maxillary incisor region.

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38c

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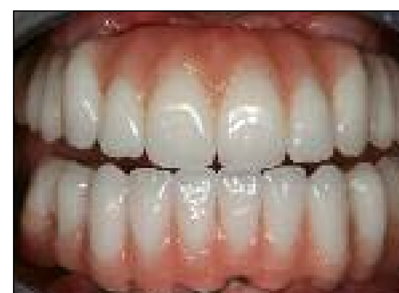

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Fig 41 Definitive maxillary porcelain restoration, which required one crown (canine) to be cemented postdelivery. (Ceramist: Dr Dario Adolfi.)

Fig 42 Occlusal view of the framework after delivery and prior to cementation of the canine crown. This framework design exhibits limited retrievability.

This type of restoration can also be designed with limited retrievability by placing the screw access holes within the confines of the crown. To remove the framework, the screw channel must be accessed by grinding through the porcelain, or the crown can be cemented with a nonhardening cement to allow for removal (Figs 40 to 42). Unless the screw channel undermines the porcelain and puts it

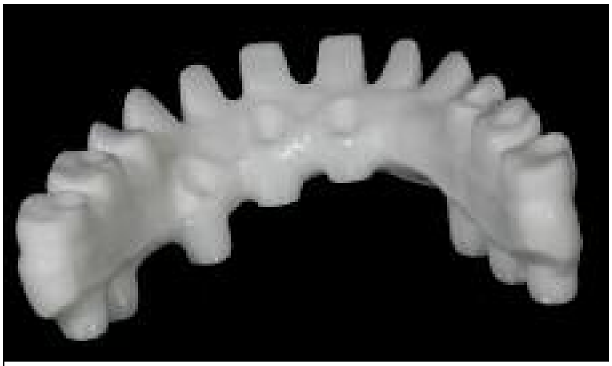

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Fig 43 Procera Implant Bridge Zirconia framework (Nobel Biocare). (Ceramist: Mr Ernst A. Hegenbarth.)

at risk for fracture, it is advisable to carry the screw channel though the occlusal surface for easy access. With all-ceramic crowns, obliteration of the access hole can be accomplished predictably with composite materials without impairing the esthetic result.

State-of-the-Art Implant-Supported Full-Arch Restorations

Currently, the most technologically advanced fixed implant-supported full-arch prosthesis is the Procera Implant Bridge Zirconia (Nobel Biocare), with individual pressed or layered porcelain for the teeth and pink porcelain for the tissue portions of the framework.

The process is very similar to the previous laboratory protocols. When fabricating a zirconium framework, factors that need to be addressed include length of cantilevers (maximum one tooth) and connector height. Also, to benefit from the superior soft tissue compatibility of zirconium, the areas in contact with the residual ridge are left in machined zirconium oxide and are not veneered with porcelain.

After the framework has been duplicated and cut back as previously described, it is inspected for adequate bulk and sufficient connector strength. Then it is scanned and milled from one piece of zirconium oxide (Fig 43). After the machining process, the framework is tried in to verify the fit and occlusal relationships. The technician has the choice of either building the crowns directly with the appropriate porcelain on the zirconium oxide (NobelRondo Zirconia, Nobel Biocare) or fabricating zirconium copings for individual crown fabrication, which are cemented onto the framework at a later stage. In same cases, both techniques can be used on the same framework. The soft tissue portion of the framework is veneered with gingival ceramic (Fig 44). The result is a beautiful, strong, and well-fitting full-arch restoration (Figs 45 and 46). If individual crowns were used on the framework, any porcelain fracture in the future can be handled as a simple single-crown replacement, which prevents facing a catastrophic failure that may require re-fabricating the entire prosthesis.

CONCLUSIONS

With today's advances in dental materials and technology, numerous options are available to fabricate implant-supported full-arch restorations. CAD/CAM implant planning, implant placement, and framework fabrication have increased the predictability of outcomes while reducing patient discomfort and treatment time. Well-fitting screw-retained frameworks fabricated using titanium or zirconium oxide are readily available and exhibit sufficient fit and strength. Material selection should be based on each patient's esthetic demands and financial considerations. Techniques exist that not only provide esthetics and function in the present, but also anticipate fractures of porcelain in years to come by providing solutions for repair.

44a

44b

44c

44d

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Figs 44a to 44d Zirconium framework with veneered with gingival ceramic. The canines and right first premolar are individual crowns to cover screw access holes.

Fig 45 Occlusal view of the definitive prosthesis with screw access holes at the canine and right first premolar covered by single crowns.

Fig 46 Frontal view of the definitive prosthesis.

The machined, screw-retained titanium framework supporting acrylic resin or composite teeth and processed with acrylic resin offers predictable, esthetic results at a good financial value. Patients that require a more lifelike appearance of their teeth should select individual all-ceramic crowns luted to a titanium framework. The most advanced technique for restoring full-arch implant cases—the Procera Implant Bridge Zirconia with single crowns and pink porcelain—is the most pleasing restoration esthetically, but is also the most costly. Explaining these choices to patients and helping them choose the best solution is ultimately the great challenge.

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