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Modified Complete-Arch Impression Technique for Facilitating Esthetic and Biomechanical Precision in Complete-Arch Rehabilitation

Basil Mizrahi, BDS, MSc, MEd

UCL Eastman Dental Institute, London, UK

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Correspondence
Basil Mizrahi, UCL Eastman Dental Institute, 256 Gray's Inn Road, London, WC1X 8LD, UK. E-mail: info@basilmizrahi.co.uk

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Abstract

Treating complex cases is clinically and technically challenging, yet highly rewarding to both patient and clinician when successfully completed. Precision in the fit of the restorations, the definitive occlusal scheme, and the esthetic result are the key elements to long-term success. Clinicians should aim to achieve the same level of precision when treating these cases as they do when treating simple cases; however, with the numerous stages and increased complexity involved comes the potential for errors to compound and magnify as treatment progresses. Areas particularly prone to difficulties are the making of a complete-arch impression and the ability to maintain patient comfort and eliminate unwanted dental emergencies throughout the time-consuming treatment. This report illustrates the techniques and concepts used to achieve esthetic and biomechanical precision when treating complex cases. Specific emphasis is placed on the importance of an accurate complete-arch impression technique, the detail of which is described in the article.

Success of dental restorations should not only be measured by immediate outcomes such as patient comfort and appearance, but also by long-term survival and stability of the definitive restorations. Long-term success is dependent on the level of precision at which treatment is carried out. The three main areas in which this precision should be focused are precision of fit, occlusal precision, and esthetic precision.

The need for precision of internal fit

Restorations are held in place by retention and resistance form. Retention is a predominantly chemical phenomenon (cementation) mainly dependent on the strength of the cement, which is subject to degradation/weakening over time. Resistance form is a physical phenomenon (preparation design) dependent on the geometry of the tooth preparation and the precision of the crown fit, both of which generally remain unchanged over time. According to Caputo and Standlee,[1] resistance form is the most important aspect in maintaining restorations in place, and Trier et al showed that 95% of crowns that came uncemented lacked resistance form.[2] The significance of marginal fit is well understood and comprehensively covered in the dental literature; however, precise marginal fit does not necessarily imply precise internal fit, especially in relation to CAD/CAM restorations.[3–5] Precision of internal fit is important in that it allows for improved mechanical resistance to dislodging forces, in turn protecting the underlying cement layer from potentially destructive and disruptive forces.[6] In addition, poor internal fit leads to a thicker cement layer, which may increase the manifestation of unfavorable cement (chemical) properties such as solubility, polymerization contraction, water sorption, and cohesive fracture[7,8]

The need for occlusal precision

Control of forces on restorations is a key factor in their longevity[9] and as such, a precise and stable occlusal relationship must be obtained in the definitive restorations. A stable occlusal scheme changes potentially harmful off-axial forces to better-tolerated compressive forces and also helps distribute forces over multiple small areas. In addition, the occlusal scheme should be "therapeutic" in that it should not create an environment favorable to self-destruction of tooth/restoration surfaces and/or musculoskeletal problems (e.g., a mutually protected articulation).[10]

Occlusal precision is not an aimless journey to an approximate area but rather a precisely navigated journey involving continual and progressive refinement toward a precise endpoint. Patient comfort should not be the sole criteria for success, as it may not be coincident with a therapeutic occlusion. Patient comfort should be coincident with mechanical precision, determined and verified by aids such as articulating paper and shim stock.

The need for esthetic precision

Esthetic appearance is subjective, and what appears esthetic to one individual may not be entirely satisfactory to another. Esthetic precision refers not to a recipe of statistically generated numbers and proportions, but rather to an individualized endpoint that satisfies the highest expectations of the dentist, the patient, and the technician. To avoid any disparity between what these three individuals envisage as the esthetic endpoint, there needs to be continual refinement of the esthetic appearance by the dentist and technician and approval by the patient before the definitive restorations are fitted.

Continual refinement towards definitive precision

To minimize errors/discrepancies during treatment and achieve high levels of precision in the definitive result, the concept of "continual refinement towards definitive precision" should be adopted. To achieve this progressive refinement of precision, the techniques and materials used during treatment must themselves become more precise and refined as treatment progresses. Each subsequent level of precision is only achievable once the previous stage is completed; hence, no attempt should be made to cut short treatment and eliminate stages. Clinical and laboratory stages must be constantly cross-checked and refined to validate and/or enhance the coincidence of the laboratory and clinical precision. This will correct inevitable discrepancies arising from material inaccuracies and limitations (e.g., material shrinkage/expansion) as well as from differences in tolerances between the stomathognathic system and the articulated casts (e.g., mandibular flexion and minor tooth movement permitted by the periodontal ligament).

Achieving a high level of precision throughout treatment usually requires long appointments and multiple stages, which in turn, lead to treatment continuing over an extended period of time. The keys to maintaining stability of the dentition as treatment progresses and precision is refined are the interim prostheses.

To maintain stability of the dentition and alleviate any time constraints, it is essential the dentist be skilled in the art and science of interim prostheses. Biomechanically stable and esthetically pleasing interim prostheses allow the teeth to be prepared and temporized over multiple appointments within the comfort zone of the patient and dentist. The material used for the interim prostheses must allow for precise remargination and both additive and subtractive modification. It must be able to maintain its esthetic properties over extended periods of time and allow easy removal without breakage. The material of choice for provisional crown and bridge restorations is methylmethacrylate acrylic resin. Some of the main advantages, in complex cases, of this material over bis-acryl-based, automix paste-paste, systems are:[11–13]

1. Lower modulus of elasticity, allowing for easier removal with hemostat-type forceps due to the slight deformation that occurs when the provisional crowns are squeezed. Bis-acryl systems are more brittle, and attempts at removing interim prostheses may either result in cracking of the material if the interim prosthesis is thin or the need to cut the interim prosthesis off if it is thick.
2. A high transverse repair strength, allowing for improved remargination and shape modification (i.e., fresh acrylic resin bonds better to previously cured acrylic resin than fresh bis-acryl bonds to previously cured bis-acryl material). This is important when remarginating provisional crowns to a high level of precision.
3. More versatile mixing/application options, making acrylic resin more amenable to modification. Acrylic resins can be used in a variety of ways depending on the requirements. A runny mix is used for remargination and minor additions, while a thick doughy mix is used for initial fabrication of the interim prosthesis. In addition, acrylic resin is less moisture-sensitive and does not require light to polymerize. This is important when remarginating intracrevicular areas.

The following clinical report will describe a rational approach to the predictable achievement of precision and illustrate the concepts and examples discussed above.

Clinical report

The patient was a 50-year-old woman in good health with a history of continuous dental treatment over many years. Her chief complaint concerned the appearance and comfort of her maxillary restorations. She felt her "bite was not right" and her "teeth looked very artificial."

Clinical and radiographic findings (Figs 1-5)

Clinical and radiographic examination revealed a combination of restorations in the maxillary arch, including porcelain veneers, all-ceramic crowns, and large composite resin restorations.

Clinical and radiographic findings included defective restoration margins on teeth 2, 3, 5 to 7, 9 to 11, and 13 to 15; caries on teeth 2, 3, 5, 6, 10, 11, and 14; and fractured porcelain on teeth 8, 9, and 11. Teeth 5, 8, and 13 had been endodontically treated. These appeared to be radiographically satisfactory and were clinically asymptomatic. Teeth 18 and 31 had large composite resin restorations with early signs of marginal breakdown. The metal ceramic crowns on teeth 19 and 30, although biologically sound, had poor occlusal morphology and color. Composite resin restorations in teeth 20 and 29, although biologically sound, had poor occlusal morphology. Periodontal condition and oral hygiene was good with no evidence of periodontal pocketing greater than 3 mm and no evidence of bleeding on probing. In addition there was no evidence of bone loss radiographically.

Occlusal analysis

Occlusal analysis revealed an Angle's Class 1 relationship with posterior wear faceting and a flat posterior occlusal morphology. Left-sided excursive movement produced contact between 6/27 and a nonworking interference between 15/18. Right-sided excursive movement produced contact between 11/22, 12/21, and 13/20. Anterior protrusive movement produced contact between 10/22 and 8/26.

Figure 1 Preoperative frontal view.

Figure 2 Preoperative view, maximum intercuspation.

Figure 3 Preoperative maxillary occlusal view.

Diagnosis

Dental caries, defective restorations, and malocclusion were diagnosed. The patient was classified as Class III according to the ACP Prosthodontic Diagnostic Index.[14]

Treatment plan

The treatment plan consisted of replacement of all the large restorations with new direct (teeth 2, 14, and 15) and indirect

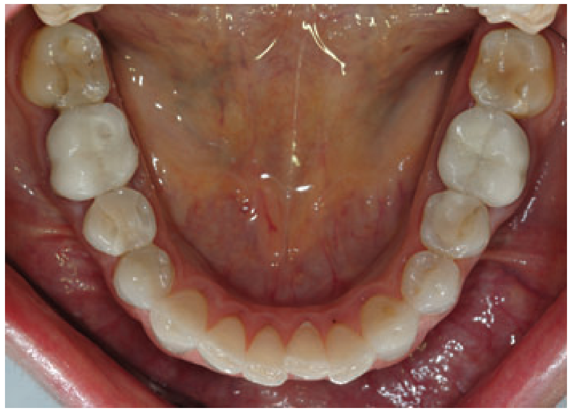

Figure 4 Preoperative mandibular occlusal view.

(teeth 13 and 5) foundation restorations, surgical crown lengthening of teeth 2 to 5 and 12 to 15, and gold onlays on teeth 2 and 15. This decision was based on the reduced tooth reduction and superior fracture resistance of gold compared to ceramic.

Conventional metal ceramic crowns were planned for teeth 3 to 5 and 12 to 14 due to the ability to use metal margins with reduced marginal tooth preparation (compared to all-ceramic crowns) required in the non-esthetic palatal and interproximal areas.[15] All-ceramic crowns were planned for teeth 6 to 11. Because the crown margins were anticipated to be on dentine, and rubber dam isolation would be impossible on the intrasulcular margins, a conventional cementation technique as opposed to a dentine adhesive/resin bonding technique was planned for the definitive restorations. As such, high strength, conventionally cementable, zirconia-based crowns were indicated.[16]

Due to the patient's financial limitations, the decision was made to restore the entire maxillary arch to optimal form, and then at some time in the not-too-distant future, restore the remaining mandibular posterior teeth (18 to 20, 29 to 31) to conform to the new maxillary arch restorations. A mutually protected articulation[10] with the following criteria was planned: disengagement of posterior teeth by the anterior teeth in excursive movements and posterior teeth to protect excessive contact of the anterior teeth in maximum intercuspation.

Mounting of diagnostic casts and initial wax-up

A dentofacial analysis was carried out with the help of a series of clinical photographs.[17,18] Study casts were mounted using a facebow and a centric relation record on a semiadjustable articulator. Despite the fact that complex treatment was being carried out, with correct knowledge and understanding, it is possible to use simplified instrumentation[19,20]

A duplicate set of study casts was fabricated and cross-mounted to the first set of casts. An initial diagnostic wax-up was made on the duplicate set of casts at a slightly increased (2-mm anteriorly) occlusal vertical dimension (OVD). The decision to increase the OVD was empirical and based on the esthetic requirement of increased anterior tooth length and the restorative requirement of adequate occlusal thickness of restorative material without compromising tooth preparation height and resistance form.[21]

Figure 5 Preoperative radiographs.

Initial chairside interim prostheses

The teeth were prepared and fitted with provisional crowns based on the initial wax-up using a methylmethacrylate acrylic resin (Tab 2000, Kerr, Salerno, Italy; Fig 6). The existing composite resin restorations in teeth 15, 14, and 2 were replaced with glass ionomer core material (Ketac Molar; 3M ESPE, St Paul, MN) to act as a core foundation for the future definitive restorations. The six anterior teeth destined to receive all-ceramic crowns were prepared with 360° deep chamfer margins. The teeth destined to receive metal ceramic crowns were prepared with shallow chamfer margins palatally, where the crown margins were to be metal, and deep shoulder margins in the esthetic, labial areas, where the margins were to be porcelain.

Cast gold dowel and cores were made for teeth 13 and 5. Surgical crown lengthening was carried out on teeth 2 to 5 and 12 to 15 to obtain a ferrule effect of at least 1.5 mm as advocated by Morgano and Brackett.[22] A healing/maturation period of at least 4 months elapsed before master impressions of the involved teeth were made.[23,24]

Following initial healing, the tooth preparations and margin locations were further refined and the interim prostheses relined. Teeth 15 and 2 were definitively prepared for gold onlays (Fig 7). It was decided to complete the gold onlays early on in treatment to provide stable posterior occlusal stops and prevent wear of the acrylic interim prostheses while further treatment was ongoing. Care was taken to obtain/maintain a stable occlusion as treatment progressed, necessitating occlusal refinement of the provisional crowns at the end of each appointment (Fig 8).

In complex cases, chairside modification may be inadequate, and it may be necessary to progress to a second set of interim prostheses made in the laboratory on a cast of the actual tooth preparations. Fabricating the definitive interim prostheses in this manner has advantages compared to making and then modifying initial interim prostheses based on an initial diagnostic wax-up:

1. In complex cases, the wax-up made on the initial study casts may not contain all the desired information required for the definitive restorations. Once the initial temporaries based on the initial wax-up have been fitted, they may undergo/require extensive morphologic and occlusal modification to encompass all the information required for the definitive restorations. This is especially true if the OVD is to be increased, as in this case.
2. Once the technician has an impression of the tooth preparations and an accurate centric relation record at the proposed OVD, he/she can then carry out a definitive diagnostic wax-up based on information gathered from the initial interim prosthesis phase.
3. This definitive wax-up should take into account esthetic, occlusal, and functional requirements and represent the precise outcome desired from the final restorations. This wax-up can then be used to fabricate precise definitive interim prostheses that can be transferred to the mouth with minimal loss of information. This is in contrast to the loss of information from the initial wax-up that accompanies chairside fabrication/relining of initial interim prostheses.
4. Extraoral processing provides increased durability, strength, biocompatibility, and esthetics.
5. Assuming all the margins of the preparations are captured, optimal marginal accuracy and emergence profile can be achieved with the interim prostheses. This ensures an optimal soft tissue response and contour, which is essential for successful master impressions.
6. A three-dimensional assessment of tooth reduction/preparation design can be made on the working casts in the laboratory. If necessary, intraoral modifications can then be made to the tooth preparation before master impressions are made.

Figure 6 Initial chairside interim prostheses.

Figure 7 Initial tooth preparations of teeth 3 and 14 ready for interim prostheses, and definitive preparation of teeth 2 and 15 ready for definitive gold onlays.

Figure 8 Occlusal assessment of chairside interim prostheses. Note unwanted excursive deviation of tooth 6 and interferences on teeth 4 and 14.

Figure 9 MRR with anterior provisional crowns in place using softened extra-hard wax and bite registration paste.

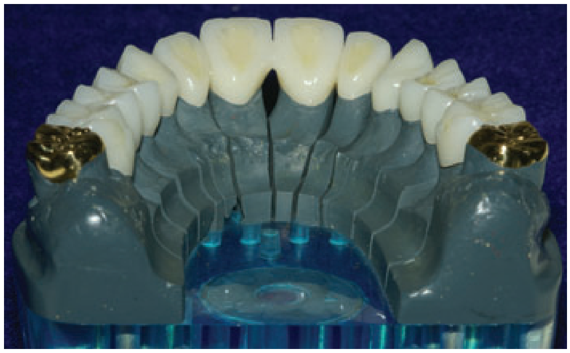

Figure 10 Laboratory fabricated, heat-processed, methylmethacrylate acrylic resin definitive interim prostheses on extreme® Mettaliepox® cast.

Figure 11 Laboratory fabricated, heat-processed, methylmethacrylate acrylic resin definitive interim prostheses on extreme® Mettaliepox® cast.

Laboratory-processed definitive interim prostheses and definitive gold onlays

A Vinyl Polysiloxane (VPS) impression (Express 2 Penta H and Express 2 Light Body; 3M ESPE) was made of teeth 3 and 14 for definitive provisional crowns and teeth 2, 15, 18, and 31 for gold onlays. Another VPS impression was made of the provisional crowns in situ. Maxillomandibular relationship records (MRRs) were made of the maxillary preparations against the mandibular teeth and of the maxillary provisional crowns opposing the mandibular teeth. The provisional crowns on the maxillary central incisors were used to maintain the OVD for the MRR of the maxillary preparations against the mandibular teeth (Fig 9).[25]

In the laboratory, a definitive and detailed wax-up outlining the proposed definitive restorations was made and used to fabricate the definitive heat-polymerized, methylmethacrylate acrylic resin, interim prostheses (SR Ivocron, Ivoclar Vivadent AG, Schaan, Liechtenstein; Figs 10 and 11). The gold onlays were fabricated using an alloy containing 77% gold, 13% silver, 8.5% copper, and 1% palladium (Jensen JRVT, Jensen Dental, Wallingford, CT).

The gold onlays on teeth 2 and 15 were cemented under a rubber dam using zinc phosphate cement (Figs 12 and 13). The thin film thickness and favorable viscoelastic properties of this cement allow complete and precise seating of well-fitting castings, and the extended setting time allows for finishing and burnishing of the gold margins prior to the cement setting.

The margins of the definitive interim prostheses were assessed for accuracy, and where needed, minor areas were remarginated. They were then cemented with a provisional cement (TempBond, Kerr, Salerno, Italy), and minor postcementation occlusal refinement was carried out (Figs 14-17). In case of any gingival recession being observed during this stage, the associated margins can be reprepared, and the overlying provisional crown remarginated.

Figure 12 Tooth 2 ready for gold onlay cementation.

Figure 13 Gold onlay on tooth 2 cemented with zinc phosphate cement.

Figure 14 Definitive interim prostheses in place cemented with Tempbond. Note excellent tissue health and attention to morphologic detail.

Figure 15 Definitive interim prostheses in place cemented with Tempbond. Note excellent tissue health and attention to morphologic detail.

Figure 16 Definitive interim prostheses in place cemented with Tempbond. Note excellent tissue health and attention to morphologic detail.

Figure 17 Assessment of occlusal relationship of definitive interim prostheses. Note improved stability compared to Figure 8.

Figure 18 Extreme® resin coping for impression of individual tooth.

The time required to achieve occlusal stability in definitive interim prostheses will depend on the refinement of the occlusion in the prior provisional phase. It is also dependent on the precision involved in transferring the MRR from the patient to the articulated models on which the interim prostheses are made.

Occlusal stability is indicated by repetition of coincident occlusal contacts over a period of time. Once this repetitive occlusal contact pattern had been achieved, the definitive interim prostheses were left in place for 2 months to ensure occlusal stability, patient comfort and gingival maturation/stability. Midway through this period, the patient returned for oral hygiene monitoring and assessment of the interim prostheses for leakage and recementation if necessary.

Master impression

Impressions of multiple tooth preparations are filled with difficulties and potential complications such as insufficient working time, inability to control moisture, trauma to soft tissues caused by excessive and overaggressive placement of retraction cord to compensate for the additional working time required to obtain a complete arch impression, distortion of material due to undercuts created by divergent teeth, increased stress for the dentist and patient, and increased patient discomfort. For these

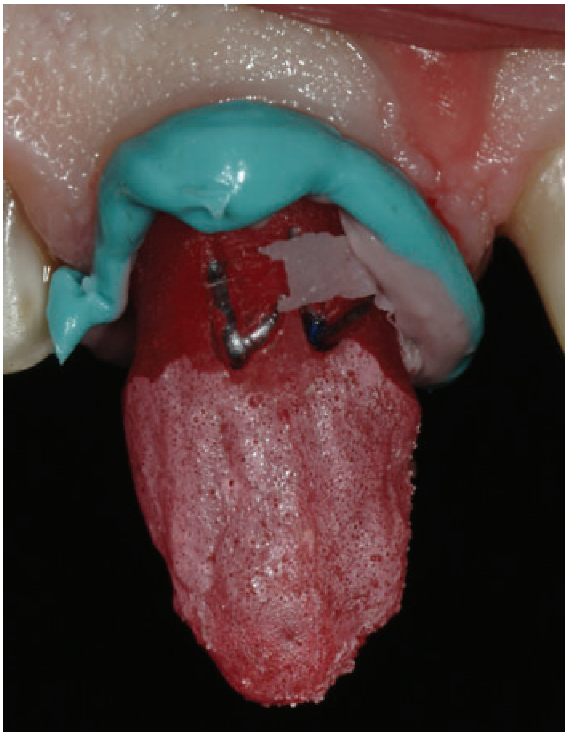

Figure 19 Impression coping with impression material in place.

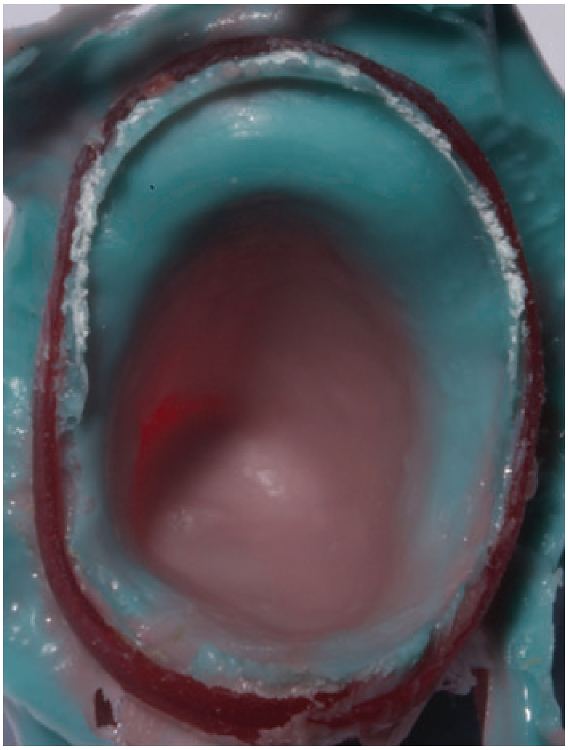

Figure 20 Master tooth impression. Note excellent detail, homogenous impression material surface, and extension beyond margin without the use of retraction cord.

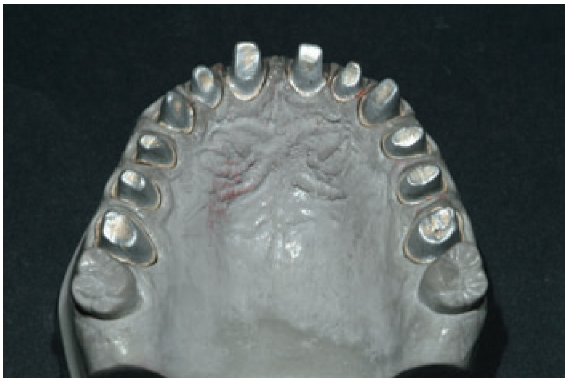

Figure 21 Extreme® esthetic model working cast with screw-retained individual silver dies. Note impression of unretracted soft tissue.

Figure 22 Individual extreme® silver dies produced from individual tooth impressions. Note metal nuts embedded in resin to allow for screw retention.

reasons, it is the author's opinion that it is not possible to predictably and precisely capture all margins in a complete-arch impression. The success of an impression is relative to the understanding of the person examining it and the intensity and magnification at which it is assessed.

The technique described and used in this case is based on the traditional copper band impression technique.[26–29] It has been modified by the author and his technician, Mr Salvatore Sgrò, to accommodate modern materials. The protocol described requires meticulous attention to detail in both clinical and laboratory stages.

Impression technique

Using the same silicone impression used to make the interim prostheses, individual extreme®[1] resin impression copings (GC pattern resin, GC, Tokyo, Japan) were made for each tooth to be impressed. The copings were made with an internal relief space of 0.5 mm, to accommodate the impression material and a seating stop on the internal occlusal or incisal surface. The internal relief space was created by placing a layer of wax (0.5-mm thick) on the die before fabrication of the coping. The copings should be fabricated well in advance of being used to allow for complete polymerization and dimensional stability.

Figure 23 Extreme® resin pick-up coping on a silver die with window to verify intraoral seating and accuracy. Note precision of marginal adaptation.

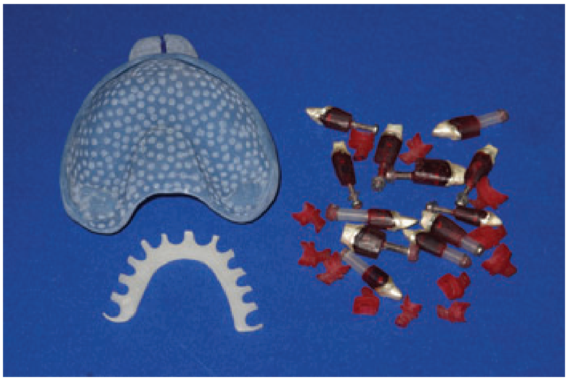

Figure 24 Extreme® custom tray and extreme® jig for coping unification and stabilization with individual, screw-retained dies and pick-up copings ready for master pick-up impression.

[1]Over his 36-year experience as a laboratory technician, Mr. Salvatore Sgró has developed a series of extremely precise protocols using unique machinery, materials, and techniques he has developed. In light of this, Mr. Sgró has been granted a patent to use the word "extreme" in conjunction with items fabricated in his laboratory using his unique protocols.

In the mouth, each coping was carefully remarginated with acrylic resin to extend just beyond the finish line of the preparations. This remargination was carried out in the same way as the remargination of a provisional crown. Using a microscope, the immediate marginal area was relieved by approximately 0.5 mm to allow space for impression material. The extension beyond the finish line was not relieved and was used to stabilize the coping as it was fully seated. The external aspect of the intrasulcular area was contoured so as to slightly distend the gingivae away from the tooth as the coping was seated, alleviating the need for retraction cord (Fig 18).

A trial impression was made with each coping using regular body VPS impression material (Express 2 Regular Body; 3M ESPE) to ensure adequate internal relief and marginal extension. Minor adjustments to the internal surfaces and marginal areas were made as needed.

The copings were then painted with a thin layer of tray adhesive, and an impression of each tooth was made one tooth at a time. Heavy body tray material (Express 2 Penta H; 3M ESPE) was used in the coping, and regular body material (Express 2 Regular Body; 3M ESPE) was syringed around the tooth. Each coping was gently seated onto its respective tooth and held in place until the material had fully polymerized. The hydrostatic pressure, together with the customized emergence profile of the copings, allowed the impression material to extend beyond

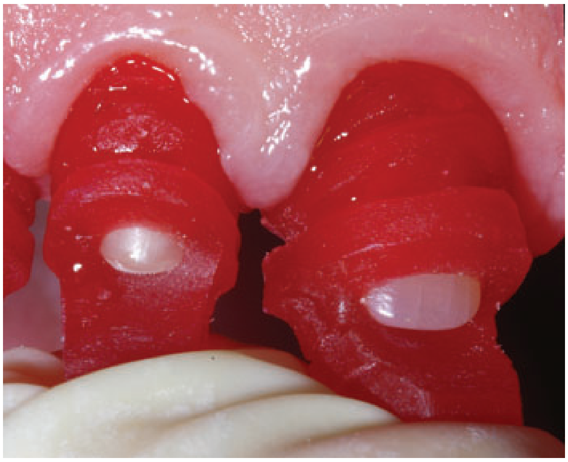

Figure 25 Intraoral seating of extreme® pick-up copings. Note precision of fit at coping window ensuring that copings are fully seated.

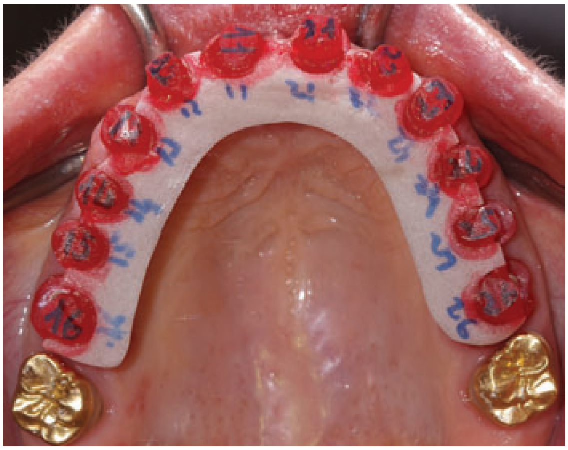

Figure 26 Unification of individual pick-up copings to extreme® resin jig with minimal amounts of acrylic pattern resin.

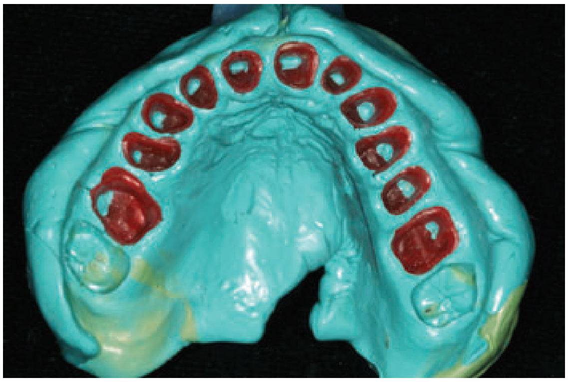

Figure 27 Pick-up impression using VPS material in extreme® custom tray (from another case).

Figure 28 Extreme® structure of Zirconia copings on anterior teeth. Note labial cutback to allow for ceramic shoulder margin application. Also note corrugations that act as stressbreakers and areas of support for the overlying ceramic. The corrugations also reduce the overall contraction of the overlying ceramic and create various centers of contraction corresponding to the individual concavities, thereby strengthening the cohesion between the coping and the ceramic.

Figure 29 Internal surface of metal copings following fit checking. Note even thinness of material and minimal material at margins.

the preparation margins without the need for retraction cord (Figs 19 and 20).

This technique has several advantages. Individual impressions can be checked and repeated if necessary. This is in contrast to a complete-arch impression, where a critical defect in one or more areas necessitates remaking the entire impression. The technique eliminates the need for attempting to simultaneously impress adjacent anterior teeth with thin interproximal tissue that could be damaged during the gingival retraction. No retraction cord is needed. Discomfort to the patient is minimal. There is no danger of material polymerization occurring too quickly as in complete-arch impressions. If necessary, the series of impressions can be made over multiple appointments. The subsequent pick-up impression allows for capture of the

Figure 30 Marking of tooth through fit checking material to indicate where tooth adjustment is required.

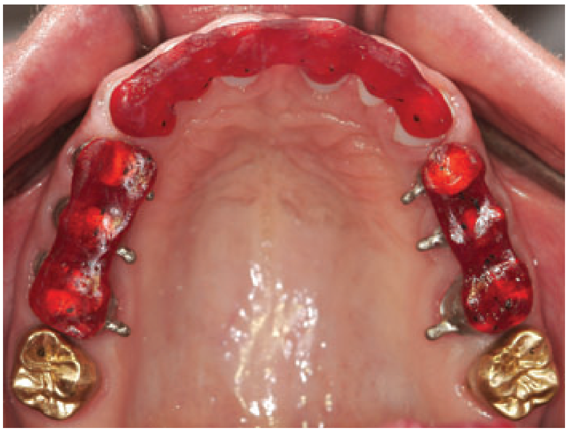

Figure 31 Acrylic resin occlusal verification jigs in place. Note point contacts coincident with those obtained on the articulated casts.

Figure 32 Intraoral checking of occlusal contacts against jigs using shim stock.

Figure 33 Ceramic try-in (bisque bake). Note excellent form after only one firing.

Figure 34 Definitive restorations in place following cementation. Note excellent tissue integration. Right lateral view.

Figure 35 Definitive restorations in place following cementation. Note excellent tissue integration. Left lateral view.

Figure 36 Definitive restorations in place following cementation. Note excellent tissue integration.

Figure 37 Definitive restorations in place following cementation. Note excellent tissue integration.

Figure 38 Definitive restorations in place following cementation. Note excellent tissue integration. Frontal view.

gingival margins in a passive, nonretracted state, allowing for more accurate fabrication of the interdental contact points (Fig 21).[30]

In the laboratory, silver-plated dies were made of each individual impression using an extreme® protocol as developed by Sgrò[31] (Fig 22). Extreme® resin pick-up copings (GC pattern resin) were then made to fit over each die. Unlike the impres-

Figure 39 Definitive occlusal contacts following postcementation refinement. Note preservation of occlusal morphology detail due to minimal adjustment required. Some missing contacts on premolars and molars are due to malposition of existing mandibular restorations (Fig 4), which were due to be replaced in the future.

sion copings used in the earlier stage, these pick-up copings are made to fit precisely over the dies with no internal spacing, as the dies will need to be repositioned into these copings at a later stage. A small window was made on the occlusoaxial angle of each coping to allow intraoral verification of fit and complete seating (Fig 23).

The resistance of silver dies to abrasion and damage is especially important when fabricating the resin pick-up copings. An acrylic resin extreme® unification jig was made to allow for intraoral connection and stabilization of the copings. An acrylic resin extreme® custom tray was made to fit over the resin pick-up copings and jig (Fig 24).

In the mouth, the copings were relocated on their specific tooth preparations, and their fit was assessed via the occlusoaxial window (Fig 25). If a coping does not completely seat, a new impression and resin coping must be made for that individual tooth before the pick-up impression can be made. The copings should remain in place on the preparations unaided. If necessary, a minimal amount of provisional cement can be used to help stabilize individual copings. The unification jig was then luted to each coping with small amounts of acrylic pattern resin (GC; Fig 26). It is important that the jig does not rest on the soft tissues, as this would prevent capture of the soft tissues in the subsequent pick-up impression.

To make the pick-up impression, regular-bodied VPS impression material (Express 2 Regular Body) was syringed intraorally around the copings and underneath the jig. Heavy-bodied material (Express 2 Penta H) was placed in the custom impression tray, which was then seated over the jig and copings. Once the material had fully polymerized, the custom tray with the embedded copings and jig was removed (Fig 27).

At the same appointment, a maxillary VPS impression was made with the definitive interim prostheses in place, and an MRR was also made of the definitive interim prostheses against the opposing unprepared teeth. By this time, occlusal stability had been achieved, and this MRR was made with the teeth in maximum intercuspation using a thin piece of gauze mesh with

Figure 40 Postoperative radiographs (mandibular radiographs remain unchanged from the preoperative radiographs at this time).

bite registration paste (Bosworth, Skokie, IL) between the teeth on either side. An interocclusal record was also made between the maxillary prepared teeth and the mandibular unprepared teeth using extra-hard wax (Miltex, York, PA) and bite registration paste. The two anterior provisional crowns in combination with the posterior gold onlays were used as stops to record the desired OVD. In the laboratory, the individual silver dies were then repositioned into the copings. A single extreme® esthetic model containing screw-retained, removable single dies of all the tooth preparations was then made using resin-reinforced stone (Resin Rock, Whip Mix Corp, Louisville, KY; Fig 21).[32]

The metal and ceramic copings were fabricated according to an extreme® protocol as described by Sgrò.[33] A double scanning technique (scanning of the die and the extreme® wax pattern) was used to fabricate the Zirconia copings on the anterior six teeth (Procera Zirconia, Nobel Biocare Göteborg, Sweden). To improve marginal precision and esthetics, the anterior teeth were fabricated with cutback margins to allow for addition of shoulder porcelain (Fig 28). The metal copings for the posterior metal ceramic crowns were cast using an alloy containing 58.2% gold, 37.4% palladium, and 3.7% gallium (OP AUREX 71, Fraccari, Valenza, Italy).

Once the copings had been fabricated, the internal fit was checked intraorally, using a silicone-based fit checking material (Fit Checker, GC; Fig 29). Studies have shown that this important step significantly improves seating of the restorations.[34] When checking/refining the fit of an all-ceramic core, the tooth surface rather than the internal surface of the coping should be adjusted, to avoid inducing cracks in the coping (Fig 30).

At this stage, the accuracy of the MMR and associated mounting of the casts was verified using jigs made in the laboratory on the articulated working casts. The jigs were made to fit over the seated copings in the maxillary arch with point contacts on all the opposing mandibular teeth. The coincidence of the point contacts on the articulator was checked with those in the mouth (Figs 31 and 32). If necessary, a remount procedure as described by Eggleston[35] should be carried out before proceeding with the porcelain application.

The porcelain application was then carried out and completed to a bisque bake stage (NobelRondo Zirconia, Nobel Biocare, on the anterior crowns and Vintage Halo, Shofu, Kyoto, Japan, on the posterior crowns). After only one firing, a ceramic try-in was carried out to assess the esthetics and occlusal functioning of the restorations (Fig 33). At this stage the definitive esthetic appearance was verified and approved by the dentist, patient, and technician. Once again the occlusal contacts were checked to ensure coincidence with those created on the articulated casts. The definitive esthetic and occlusal precision was completed in the laboratory during the final firings of the ceramic.

At a subsequent appointment, the definitive restorations were cemented with a resin-modified glass ionomer (Fuji Plus, GC; Figs 34-38). Following cementation, the definitive and precise occlusal adjustment was carried out (Fig 39). This is an essential step, as there are always minor occlusal discrepancies following cementation. The adage that "the mouth is the best articulator" is only applied at this very final stage of postcementation occlusal adjustment. If attention to detail has been followed, and occlusal precision verified at all stages, this postcementation occlusal adjustment should be minimal. Postoperative radiographs revealed that there were no cement remnants, and that all margins fit well on the underlying teeth (Fig 40).

Recall and maintenance

The patient was placed on a 6-month maintenance and recall schedule. Initially her occlusion was assessed and refined at 6-month intervals and thereafter, as the longevity of the occlusal stability improved, on a yearly basis.

Discussion

In complex complete-arch restorations, it is essential to maintain control at all times and ensure precision at all stages.

Treatment should be carried out in stages ensuring the success of each stage before proceeding to the next stage. The first stage involves placing initial chairside interim prostheses on all the teeth involved. This then allows access for adjunctive treatment such as endodontic and periodontic treatment if needed. During this stage, the visualization of the proposed definitive esthetic result begins. Once the underlying teeth and gingiva are biomechanically sound, and the tooth preparations have been completed, impressions are made for the next stage of treatment, which involves fitting of laboratory-processed definitive interim prostheses. These definitive interim prostheses move the treatment one step closer to the definitive result, and treatment becomes more focused on the finer details such as precise margin placement and occlusal precision. During this stage, mandibular position stability and reproducibility is established, thereby allowing for precise occlusal contacts to be established. Definitive tooth preparations are completed, and patient approval of the esthetics, comfort, and function of the interim prostheses is obtained based on the fact that they are the blueprint for the definitive restorations. The final stage involves cementation of the definitive restorations and postcementation occlusal adjustment.

Although multiple stages and steps allow for simplification of a complex case, they have the potential for increasing errors and discrepancies as the case progresses. It is, therefore, essential to ensure accuracy and precision at each stage to eliminate all avoidable discrepancies. Despite this attention to detail, there will still be unavoidable discrepancies between the nonrigid stomatognathic system and the rigid mechanical articulators and casts used in fabrication of the restorations. These discrepancies need to be monitored and eliminated as treatment progresses. If this is done meticulously, only minimal postcementation adjustment will be required, and minimal adaptation by the patient will be required. Besides fulfilling the instant goal of good esthetics, the long-term prognosis of the restorations will be optimized based on the precision of the occlusal scheme and the fit of the restorations.

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