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Treatment Planning Complications and Surgical Miscues

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P.P. Binon, DDS, MSD

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Since the advent of osseo-integrated implants, many major innovations and improvements have taken place. From a surgical perspective, the instrumentation required to make the osteotomy has improved in cutting efficiency and heat reduction.[1] Bioactive implant surfaces have been developed that result in faster integration and immediate loading.[2,3] Flapless surgery and improved long-term predictability of virtually all the major implant systems are now a reality.[4,5] The ability for implant site development with predictable particulate and block grafting techniques and the use of recombinant proteins along with enhanced soft tissue modification has expanded applications.[6-10] The interface stability problems initially encountered with the external hexagonal connections, when applied to single and fixed partial denture (FPD) applications, have also been resolved with the development of the internal connection.[11,12] Three-dimensional computed tomography (CT) radiographic imaging and computer-assisted treatment planning software have revolutionized treatment planning and surgical placement.[4,13,14]

As a result, in the course of 25 years, dentistry has undergone several major paradigm shifts. In the past it was acceptable to place implants with little consideration of the restorative aspects of treatment, resulting quite often in exceptional efforts on the part of the prosthodontist and restorative dentist to arrive at a tolerable functional and esthetic result. Today, the expectations of a more sophisticated and esthetic-oriented patient base that demands a much higher level of treatment has significantly altered those initial paradigms.

One significant factor remains unchanged. Restoration of a dysfunctional dentition with conventional fixed or removable prosthodontic treatment, or with implant-supported restorations requires the same basic treatment protocols that are consistent for all implant restorations. The common factor is that implant dentistry is a restorative prosthodontic treatment modality with a surgical component. The foundation is created by the surgical placement of the implants which has to be dictated by specific restorative requirements, both from a functional as well as an esthetic perspective. Without that symbiotic interrelationship, the outcome will be less than ideal.

The hallmark of successful treatment lies in an organized and complete diagnosis which then results in a comprehensive treatment plan. To arrive at the diagnosis, the following has to be considered: soft tissue pathology, caries, periodontal evaluation, radiographic evaluation which may include CT imaging, endodontic evaluation, occlusal considerations, parafunctional habits, transmandibular joint (TMJ) evaluation, vertical dimension of occlusion, intra-arch space, jaw malrelationships, lip drape and lip support, patient expectations, esthetic evaluation, mounted study casts and bite records, and a diagnostic wax-up of the partially edentulous area or a trial prosthesis. From a surgical perspective, a medical assessment,

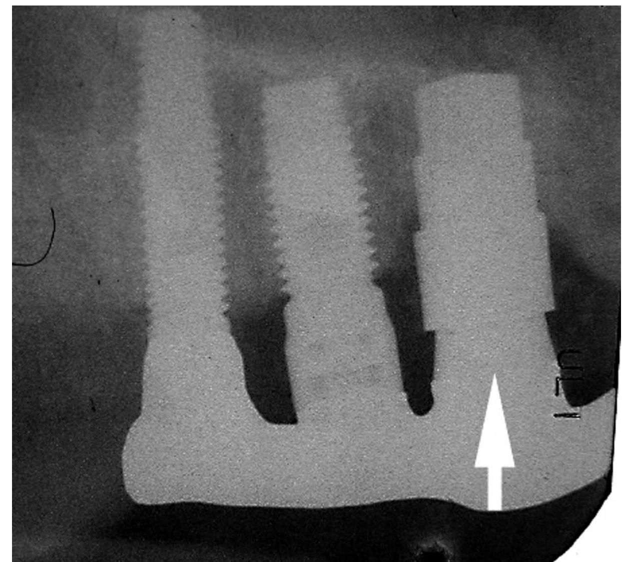

FIGURE 1. The diameter of the implant is too wide for the available bone. Bone loss is apparent around the implant.

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Assistant Research Scientist, Department of Restorative Dentistry, University of California at San Francisco, San Francisco, CA and Adjunct Professor of Prosthodontics, Graduate Prosthodontics, Indiana University, Indianapolis, IN.

Address correspondence and reprint requests to Dr Binon: Department of Restorative Dentistry, University of California at San Francisco, San Francisco, CA.e-mail: binondds@yahoo.com

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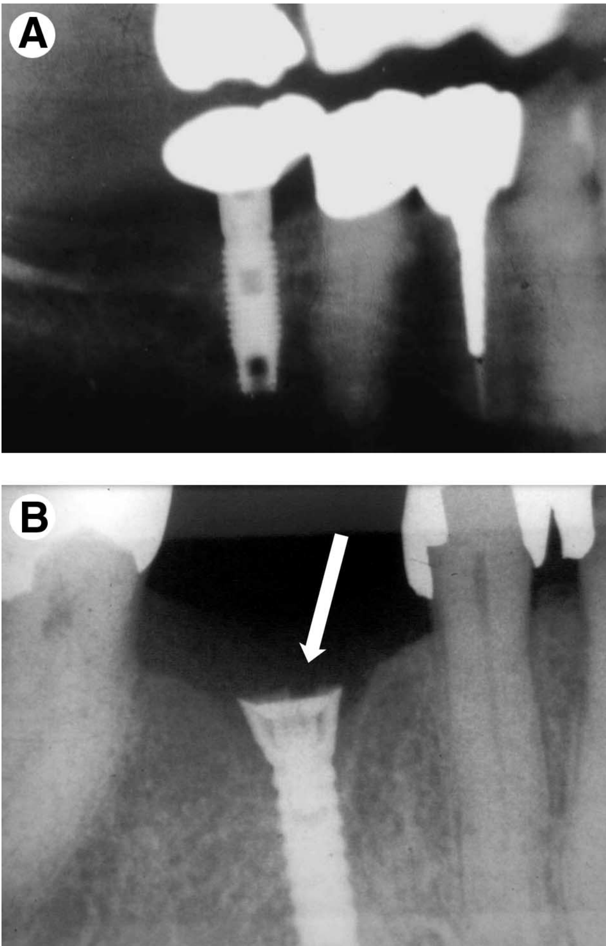

FIGURE 2. Too narrow an implant for the available space and required load bearing. *A*, Occlusal functional area on an inappropriate implant diameter results in mesial and distal cantilever. *B*, Functional loading resulted in fatigue fracture of the implant walls. The diameter of the implant is inadequate for the functional unit it replaces.

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the patients healing and stress capacity, current medications, anesthesia risk factor, and bone quality and quantity have to be evaluated.

The primary responsibility for dental evaluation and treatment planning lies with the prosthodontist and or the restorative dentist. After the initial treatment plan has been developed with the patient's goals and objectives in mind, the surgical aspects of treatment are then assessed. At this point, communication between the restorative and surgical counterparts is crucial for an ideal result.[16]

Implant placement, without restorative input, results in a myriad of significant problems and complications to the detriment of all parties involved. This article identifies major surgical miscues that affect prosthodontic outcome, and codifies them in an organized manner.[16]

Inappropriate Implant Selection and Placement

Selection of the implant is based on a variety of factors such as available bone, type of restoration, load bearing capacity, implant platform and nonrotational feature, the tooth it replaces, as well as the esthetic requirement. From a biomechanical standpoint, it is desirable to place the widest and the longest implant that the available bone volume and anatomic features permit. Obviously, the greater surface area available for integration the greater the dissipation of the functional load. A wide variety of diameters and lengths are available from most of the manufacturers today.[18]

If an implant is too wide for the available bone, the result is implant dehiscence through the bone, which can contribute to implant failure (Fig 1). Conversely if the implant is too narrow to support the functional load, the result can be progressive bone loss and failure of the implant itself due to fatigue fracture (Fig 2).[19]

Clinical studies have shown that implants of 10 mm or more in length may have a significantly greater success rate and a correlation between length and

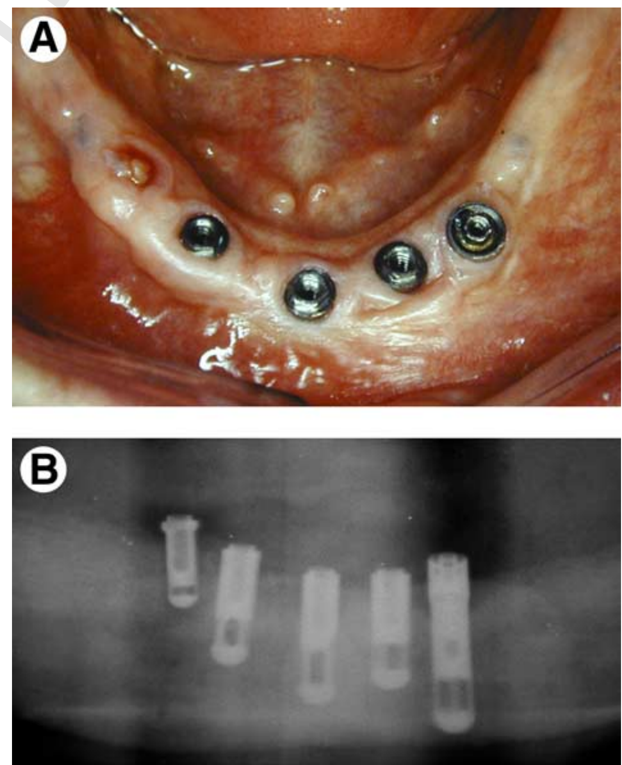

FIGURE 3. *A*, Inappropriate length implants for the bone volume available. Four of the 5 implants also were not inserted to the correct depth. *B*, Right distal implant late failure resulted in replacement and prosthetic re-treatment.

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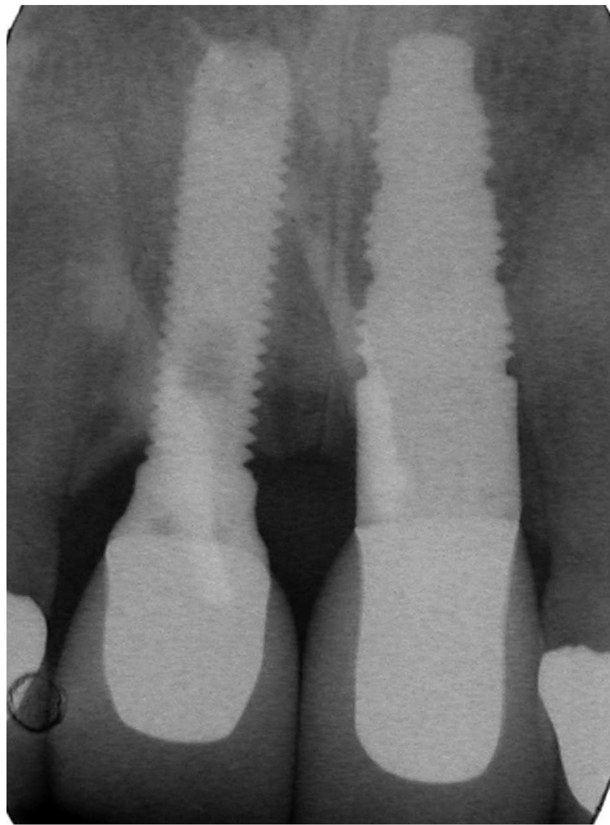

FIGURE 4. Mismatched implant diameters in the esthetic zone. This creates significant restorative emergence profile and soft tissue esthetic problems.

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long-term function is evident. It is therefore appropriate to place implants of the greatest length possible.[20] Failure to apply these principles can result in implant loss and failure (Fig 3). Consideration has to be given to the emergence profile of the restoration if optimal esthetics is to be achieved. Mismatched implant diameters, especially in the esthetic zone, will lead to uncontrolled emergence profiles, soft tissue disharmony and significant uncontrollable esthetic problems (Fig 4).

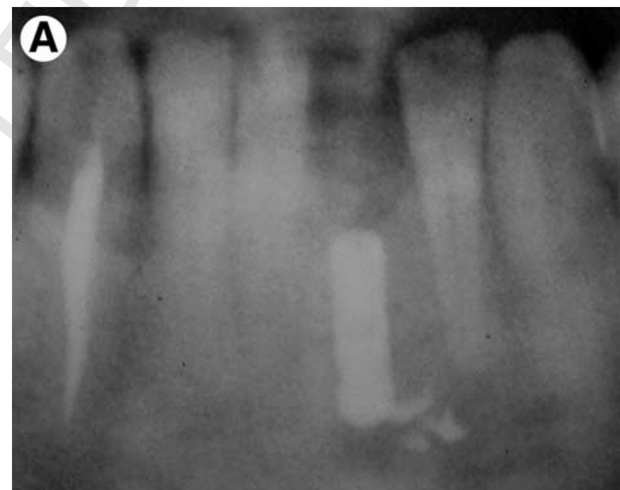
For single tooth restorations and FPD applications, an anti-rotational engagement between the implant and the abutment is necessary to enhance the stability of the restoration.[21] Placement of an implant devoid of this feature, especially for single tooth restorations, results in a nonrestorable and untenable situation. The resulting options are to remove the implant and replace it with the appropriate type or abandon implant restoration and revert to a FPD (Fig 5).

In selecting an implant, consideration also has to be given to the implant abutment connection. This is critical when angulation changes have to be made in order to meet restorative requirements. Failure to select the appropriate implant leads to significant additional laboratory work and additional expense and a compromised design (Fig 6).

Another implant type selection consideration occurs when additional implants need to be placed due to conversion from a removable prosthesis to a fixed prosthesis or when more implants are required due to imminent failure of one or more implants. In these circumstances, it is prudent to select compatible implant types rather than multiple different designs of implants. Mismatching implants results in added chair time, additional instrumentation, complications regarding tracking part, added laboratory time, and costs (Fig 7).

Number of Implants Placed

A variety of prosthodontic protocols have been established to restore the fully edentulous mandible and maxilla.[22-25] In general, the maxillary arch can be restored with a bar-supported removable prosthesis with 6 to 8 implants depending on the quality and



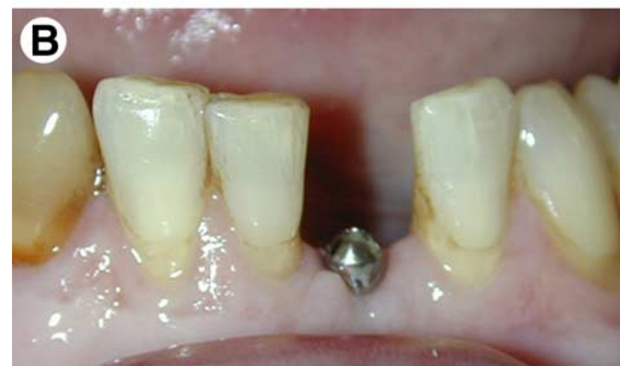


FIGURE 5. *A*, Inappropriate implant selection for single tooth replacement function. *B*, Implant had no anti-rotation feature and was removed.

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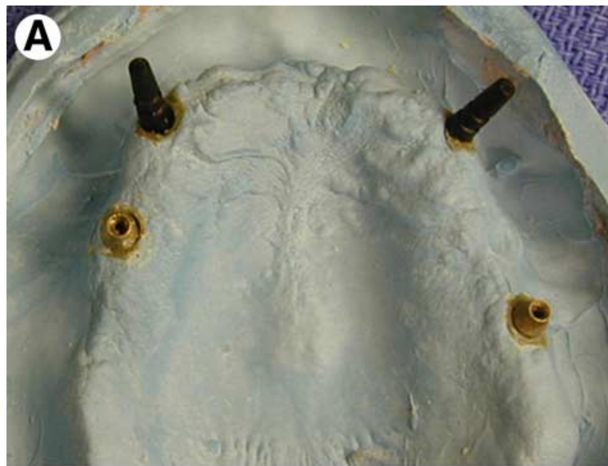

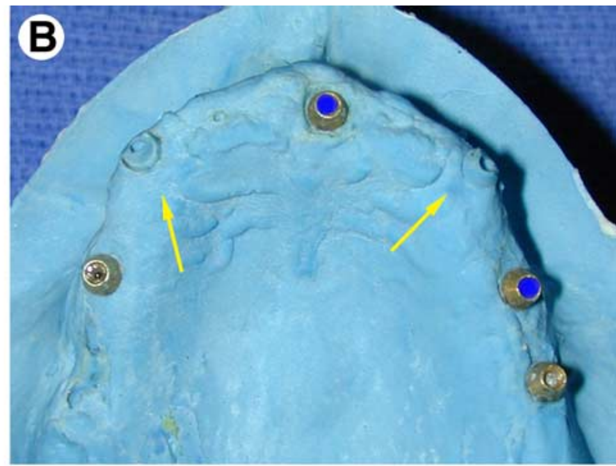

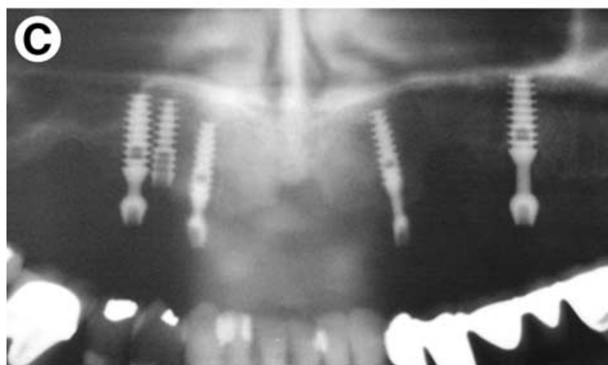

FIGURE 6. *A*, Press-fit design negated angulation changes required to attach a screw-retained tissue bar for an overdenture. *B*, Flare of the anterior implants resulted in abutment head modifications (*C*) that compromised the screw retention threads and required custom lingual set screws to retain the bar.

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quantity of bone available. For completely fixed applications (Ceramo Metal Bridge) typically 4 implants in the cuspid to molar area on each side are required to support the FPD (Fig 8). When the anterior cantilever arm is significant a single anterior implant can be added. This applies also for a fixed mandibular partial denture restoration. In the mandible, support for an implant supported hybrid bone anchored bridge is usually obtained from 4, 5, or 6 implants in the symphysis area, depending on arch size and bone volume (Fig 9). Using an excessive number of implants to support the functional load is not desirable and can lead to both esthetic and hygienic complications (Fig 10).

Optimal number of implants and appropriate spacing is also critical in the partially edentulous pa-

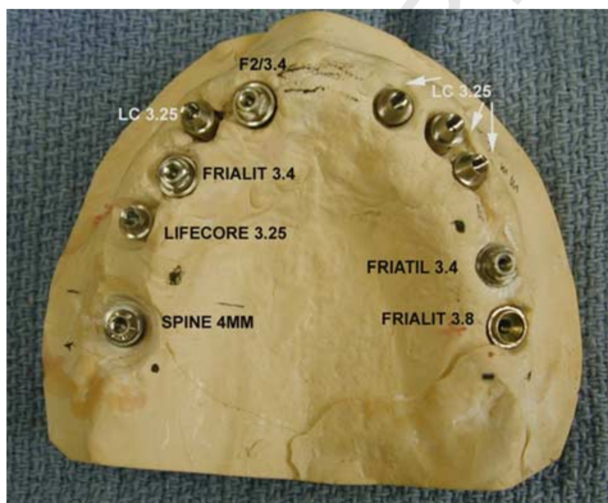

FIGURE 7. Upper arch with several different implant designs in place. This resulted in additional instrumentation, a variety of component parts, added restorative chair time, and unnecessary complexity.

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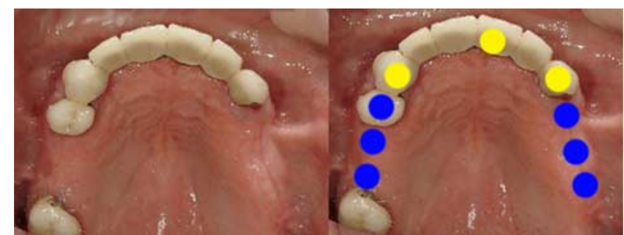

FIGURE 8. Failing partially edentulous arch to be restored with sequential implant placement. Blue circles indicate placement of the first series of implants. After extraction of the cuspids, additional implants were inserted (yellow) to restore the arch with a porcelain-fused-to-metal bridge. Adjacent implants in the anterior segment would compromise ability to create esthetic soft tissue contours.

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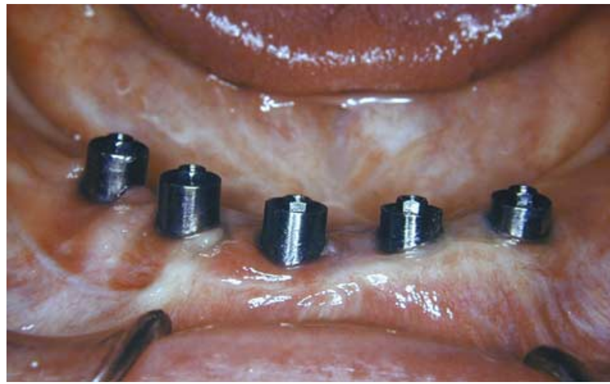

FIGURE 9. Typical arrangement of implants in the symphysis area.

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tient.[23,25] In those applications however, the protocols are less well defined in the literature.

In general, for maxillary FPD a 1 to 1 or 1 to 2 implant to tooth ratio applies. Whenever grafted bone supports the implants, current protocols usually recommend a higher number of implants, although evidence-based analysis is lacking.

Decisions relative to the number of implants are restoratively driven. It is expected and necessary that the surgeon communicate with the restorative doctor whenever there are differences in the number of implants prescribed, prior to surgery. It is not acceptable to increase or decrease the number of implants without consensus. The patient's predetermined restorative treatment plan and financial commitment cannot be altered without prior consent of the restorative doctor and the patient.

Encroachment

In partially edentulous cases the risk of root injury is always present. Adequate diagnostic planning with radiographic marker stents derived from diagnostic wax-ups is necessary to avoid damage and tooth loss (Fig 11). Complications of this type usually result in additional implants being required along with additional restorative costs and potential professional liability.

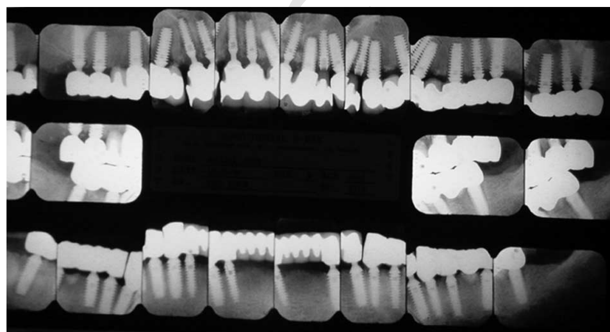

FIGURE 10. Example of overzealous treatment planning. More implants than necessary were placed to restore the maxilla and the mandible. Spacing, loading axis, and angulation was also problematic. Of the 19 implants placed, 11 failed within one year.

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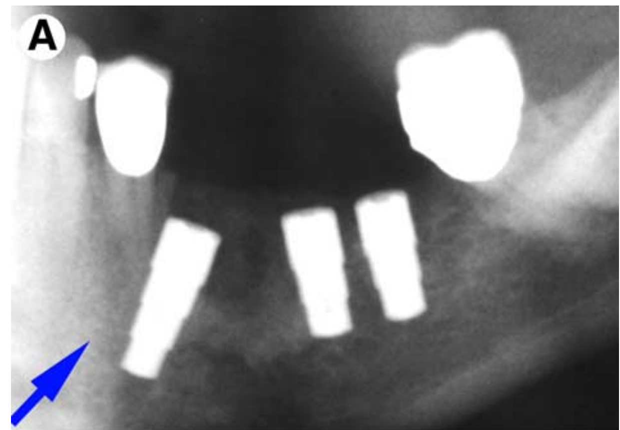

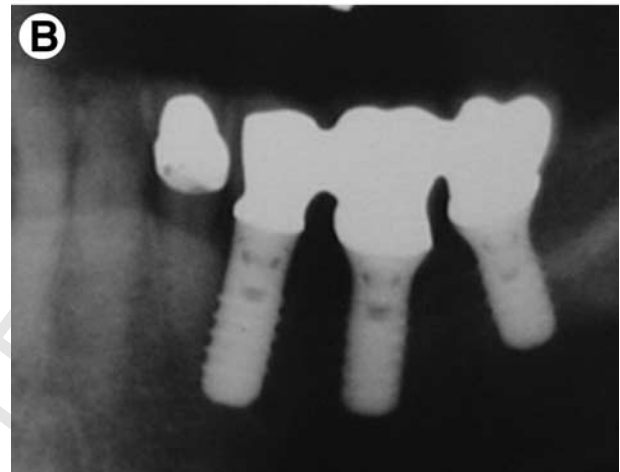

FIGURE 11. Encroachment on natural teeth. In both instances, the teeth had to be removed. *A,* The implant and the tooth failed and both had to be replaced with additional implants. *B,* After extraction of tooth twenty-eight, the implant bridge was remade and a pontic was added.

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Disregard of surgical stents that mark the location and axial orientation of implants in fully edentulous cases can also lead to encroachment of adjacent implants (Fig 12). This occurrence may result in one or more early implant failures, a significant time delay for completion of treatment, greater laboratory costs and additional chair time for the restorative dentist.

Even more compromising is encroachment of the tongue. In two of the examples cited, no prosthetic consultation or collaborative treatment plan was developed. The patient was referred after the fact for restoration. In the first case, the implants were

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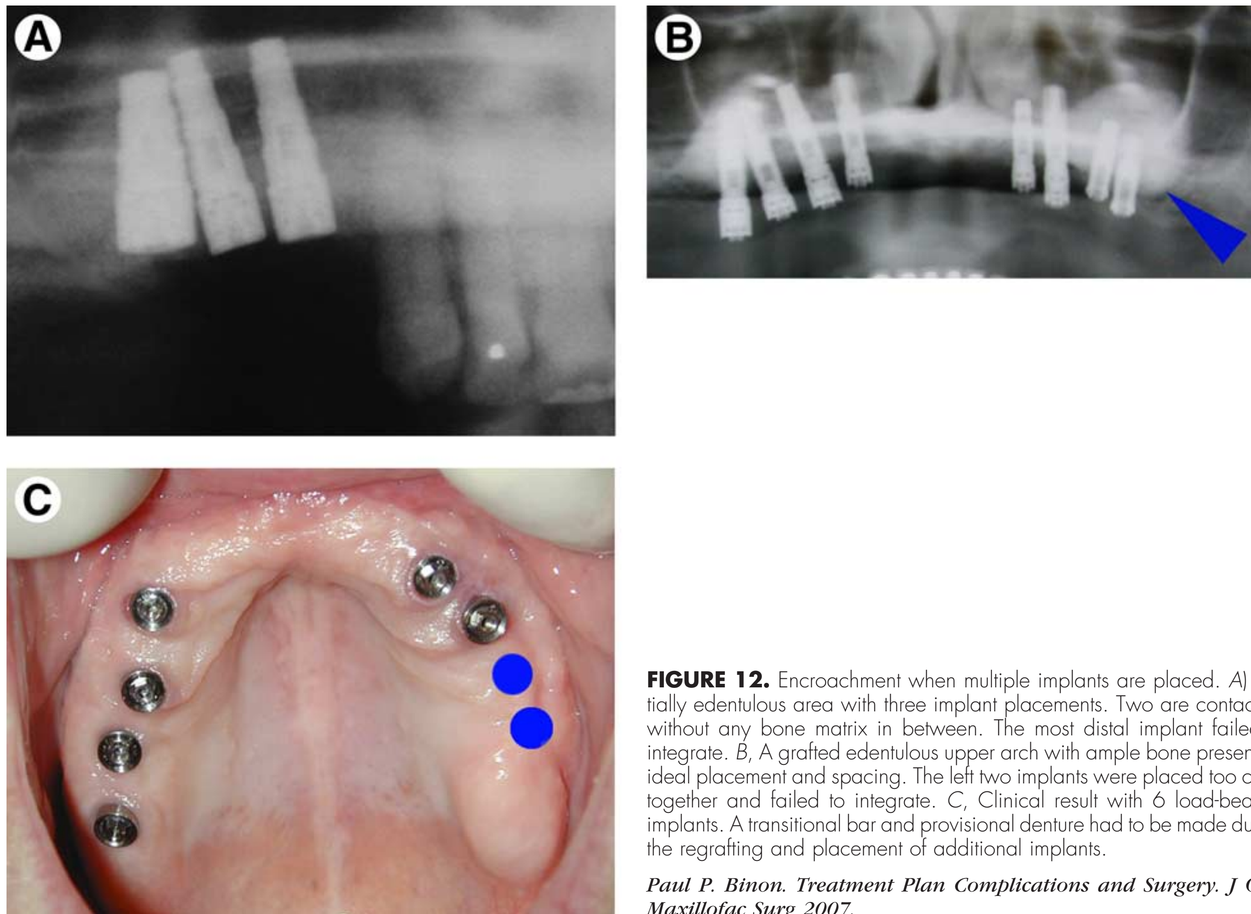

FIGURE 12. Encroachment when multiple implants are placed. *A)* Partially edentulous area with three implant placements. Two are contacting without any bone matrix in between. The most distal implant failed to integrate. *B,* A grafted edentulous upper arch with ample bone present for ideal placement and spacing. The left two implants were placed too close together and failed to integrate. *C,* Clinical result with 6 load-bearing implants. A transitional bar and provisional denture had to be made during the regrafting and placement of additional implants.

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so palatally placed that restoration was impossible and the implants were removed and the patient retreated (Fig 13). In the second case the implants were placed in line with the distal of the cupids, resulting in a significant cantilever and an exit point in a sensitive phonetic area. To restore these implants, two thin palatal straps were incorporated into the 4-unit FPD. This resulted in a functional but compromised outcome (Fig 14).

Posterior tongue encroachment may also occur. This case illustrates 2 points from a restorative perspective. The patient presented with 2 unrestored implants in the left upper quadrant and bilateral sinus augmentations. Her goal was to have single restorations in both posterior quadrants. After an exam, study casts, radiographs, and a diagnostic wax-up (Fig 15) and surgical stent (Fig 16) were made. Referral and appropriate communications were established with a different clinician as to the location, number, and type of implants to be placed. It also was pointed out that one of the previously placed posterior implants (fifteenth position) was inappropriately located too far palatally and consequently encroached on the posterior tongue space. The locations of the additional implants were re-affirmed prior to surgery. The postinsertion panographic film indicated that one implant had not been placed (fifth position) but the mesiodistal spacing of the 3 implants that were placed appeared to be acceptable and in the locations indicated by the surgical stent. At uncovering, it was obvious that although the general location of the implants was correct, the axial orientation was not (Fig 17). All of the additional implants placed were palatally located and lingually inclined from 35 to 45 degrees off axis (Fig 18). The additional implant placed on the left (position fourteen) mirrored the tongue encroachment location of the implant in the fifteenth position. It was apparent that the surgical stent was not used and that the pre-surgery instructions were ignored. To restore the case, custom abutments were made that were severely off axis. The resulting crowns were grossly over-contoured (Fig 19). Even with a maximum effort to minimize the palatal intrusion, a notable difference in tongue space was seen (Fig 20). Consequently, a maxilla with ample bone to place implants in ideal locations was compromised because the surgical prescription was ignored.

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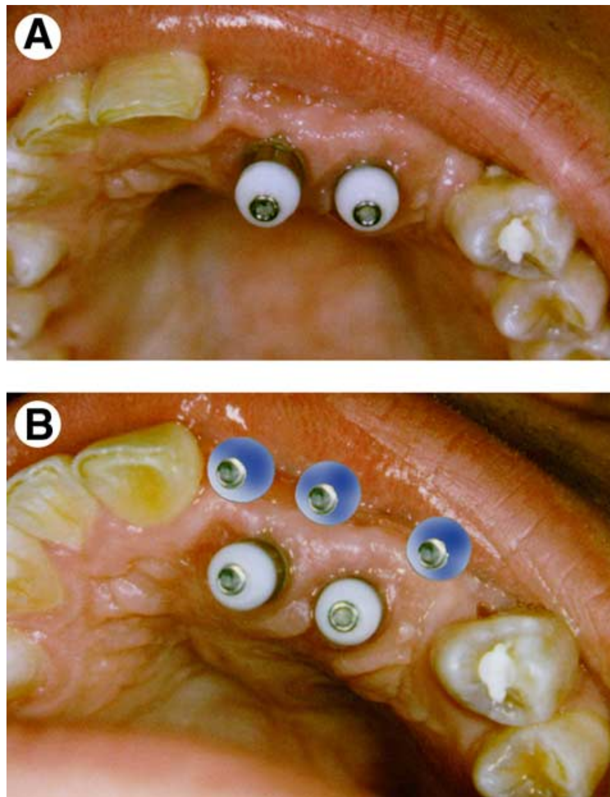

FIGURE 13. *A*, Inappropriate location of 2 implants that were intended to support a restoration from tooth position 9 to 11. The implants were in the palate and not the alveolar ridge. *B*, Indicates where the implants should have been located. It is obvious that block or veneer grafts were indicated before any implants were inserted. Both implants were removed. This resulted in additional unnecessary surgeries and substantial time loss to completion.

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Vertical Orientation

In partially edentulous arches, it is important to be aware of the crestal bone levels of the adjacent teeth.[26] Not only is this of critical importance for the preservation of the papillae but it is also a factor in hygiene maintenance. If the implant is placed too deep relative to the adjacent teeth, a peri-implant pocket develops that leads to further bone loss and quite often, a fistulous tract (Fig 21). In the case illustrated, the site would have been better served with a particulate or block graft prior to implant placement. Another frequent complication is when the implant is placed below the bone crest and crestal bone has to be removed in order to permit mating of the impression coping and the abutment. The second example illustrates that this can seriously compromise adjacent teeth and ultimately several millimeters of bone are sacrificed (Fig 22).

Equally challenging is when implants are not placed deeply enough. In the example shown in Figure 23 (panel *A*), both implants were placed 40% to 50% in the posterior mandible. The implants were placed without prior knowledge or direction of the general dentist. This patient was left without restorations for many months and finally sought out another dentist to restore the implants. After examination, the options presented were to remove the implants and place block grafts to correct the mandibular insufficiency or to place provisional restorations and load the implants and evaluate the response (Fig 23 *B*). Within months the implants failed and the patient rejected any further implant treatment. It's obvious that the original diagnosis and treatment plan was inadequate. The patient required grafting prior to implant placement. Communication with the patient's restorative dentist was also lacking.

Inadequate Spacing in the Anterior-Posterior Spread

In the mandibular arch one of the most common restorations treatment-planned for the edentulous arch is the classic hybrid fixed prosthesis. To support a fixed lower denture 5 or 6 implants are placed between the mental foramen. Because it is a cantilever restoration, the greatest distance between the

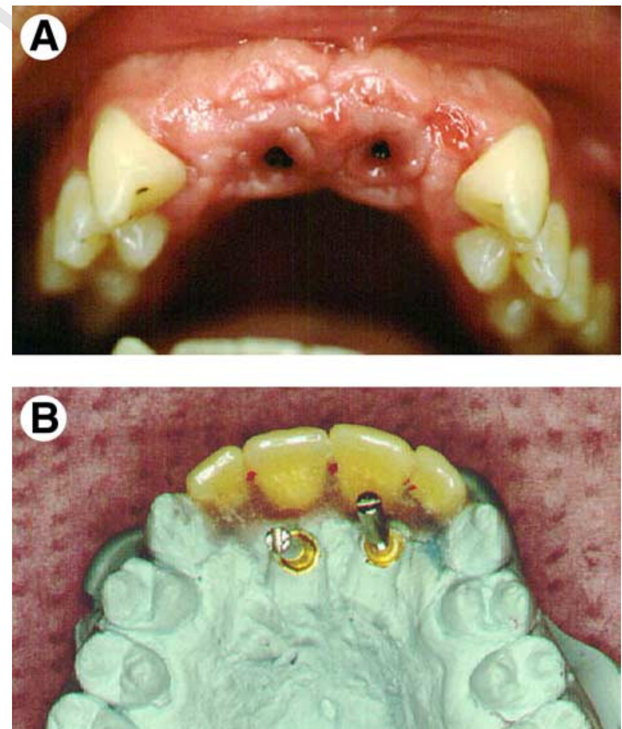

FIGURE 14. *A*, Two palatally located implants inserted after ridge augmentation. Their location approximated the distal of the cuspids. *B*, Restored with a 4-unit porcelain-fused-to-metal bridge supported by two palatal straps; location did compromise phonetics and restoration was quite difficult to minimize the consequences of the surgical miscue.

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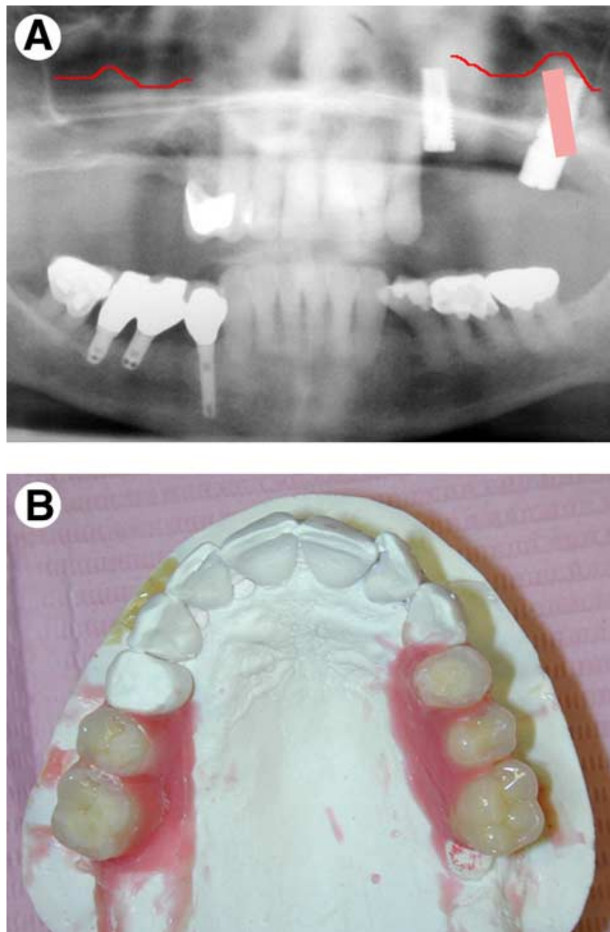

FIGURE 15. Example of posterior tongue encroachment that could have been avoided. *A*, Radiograph indicates the palatal placement of the number 15 implant, placed before the second surgical experience. *B*, Diagnostic wax-up, used to make radiographic and surgical stent. It illustrates the correct location of the posterior teeth.

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most anterior and the most posterior implants results in the best mechanical force distribution.[27,28] When implants are placed in a near straight line the cantilever length has to be limited to avoid overload and component failure. Figure 24 shows two examples of inadequate implant spacing when adequate room existed between the foramina. The net result was unnecessary crowding of the implants and most importantly, reduction of the anterior-posterior (AP) spread. In both instances, adequate space was available to place the posterior implants more distally. Had the implants been spaced more appropriately, the AP spread would have been doubled.

Coincident with inadequate spacing is the close cervical proximity of the abutments resulting in soft tissue management problems and hygiene difficulties (Fig 25). Ideal spacing between implants is 3 mm or more.[26,29] When this is violated, the papilla is com-

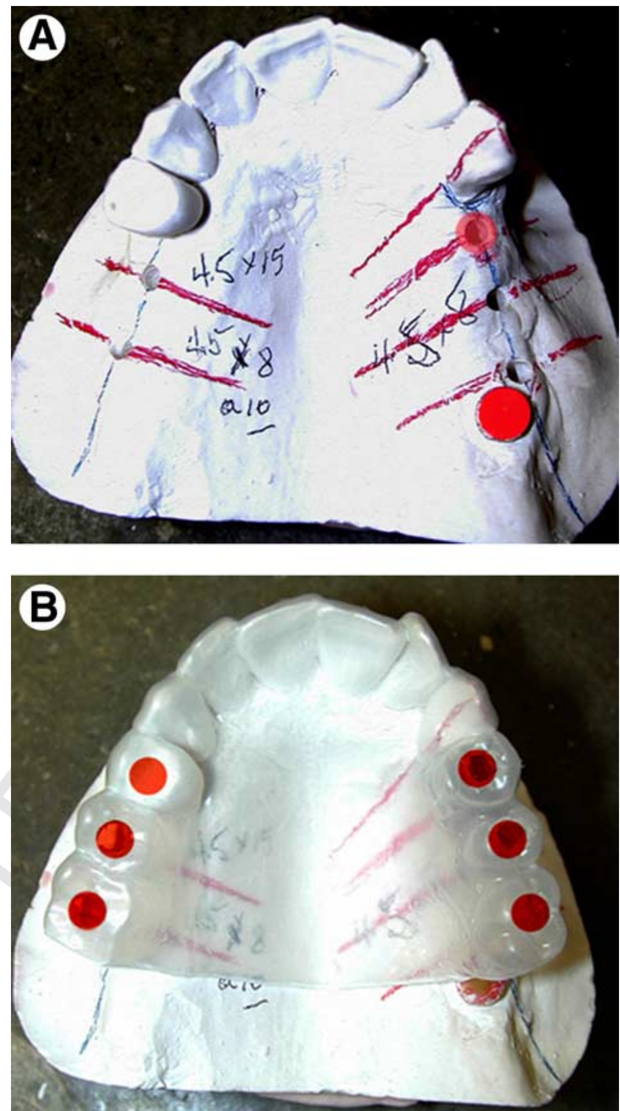

FIGURE 16. *A*, Cast marked with the location of the prescribed new implant locations. Diameter and length are also noted on the cast. *B*, Surgical stent provided to the surgeon.

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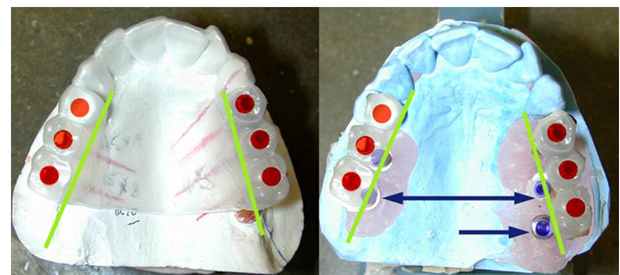

FIGURE 17. Lingual contours illustrated by the yellow line had implants been placed in prescribed locations. The photo on the right demonstrates the resulting encroachment on tongue space due to the palatal placement of the implants.

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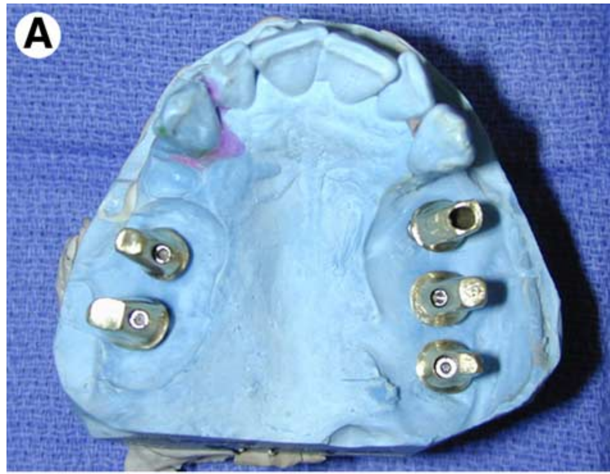

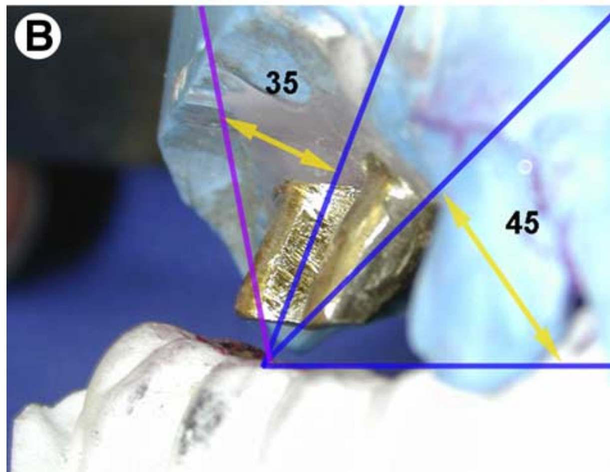

FIGURE 18. *A*, Abutments required severe angle corrections. Note the screw access locations in abutments 3, 4, 14 and 15. *B*, Side view indicates angulations of 35 to 45 degrees.

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promised and progressive long-term apical tissue migration is often the result (Fig 26).[29,30] Even when hourglass shaped custom abutments are used, hygienic access is difficult. Proximity problems are typically the result of inadequate diagnosis and coincident with not using radiographic and surgical stents. From a surgical standpoint the implants may be considered a success. However, from a restorative perspective it resulted in a significant prosthesis design challenge along with potential long-term complications.

Inadequate Intra-Arch Distance

Another complication that can be traced directly to inadequate diagnosis and failure to have collaborative treatment planning with the restorative dentist is the placement of implants without attention to the interarch and interocclusal space. This is especially critical

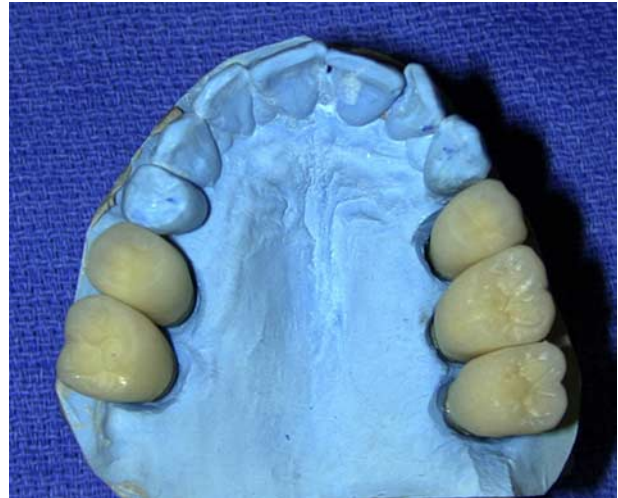

FIGURE 19. Bilateral palatal location of the implants resulted in grossly over contoured crowns.

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in partially edentulous patients where there is excessive loss of vertical dimension of occlusion, distortion of the occlusal plane or migration of the opposing dental segment. Whenever multiple implants are to be placed, it is necessary to have mounted casts with a diagnostic wax-up in order to evaluate the implant location, the occlusal scheme, and determine if there is adequate vertical room for the abutment and the clinical crown. In tight spaces, a screw retained directly to the implant restoration can be placed. However, that results in crowns that are short, bulbous and esthetically unattractive, which is not an accept-

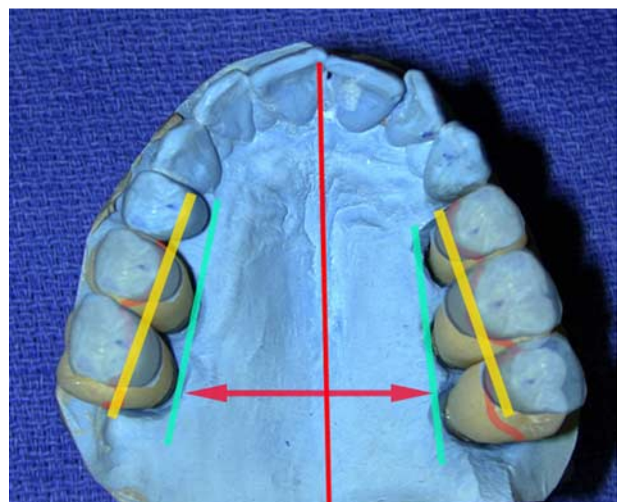

FIGURE 20. Overlay of what the clinical crown size would have been had the implants been located in the correct location. It graphically illustrates the extent of the difference in size and the degree of tongue encroachment.

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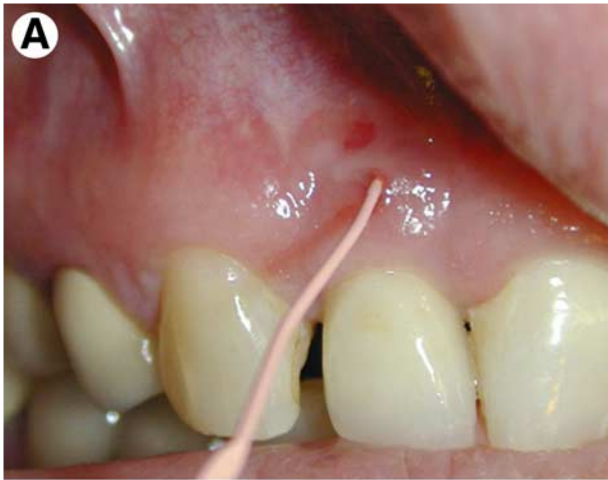

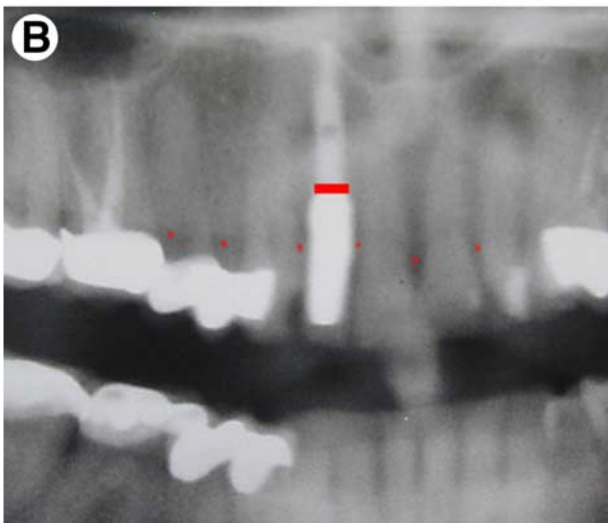

FIGURE 21. *A*, Implant located too far apically relative to the adjacent teeth. This resulted in an unmanageable soft tissue pocket and a fistulous tract. *B*, Red line indicates the implant/abutment interface. Crown/root relationship is also beyond normal limits.

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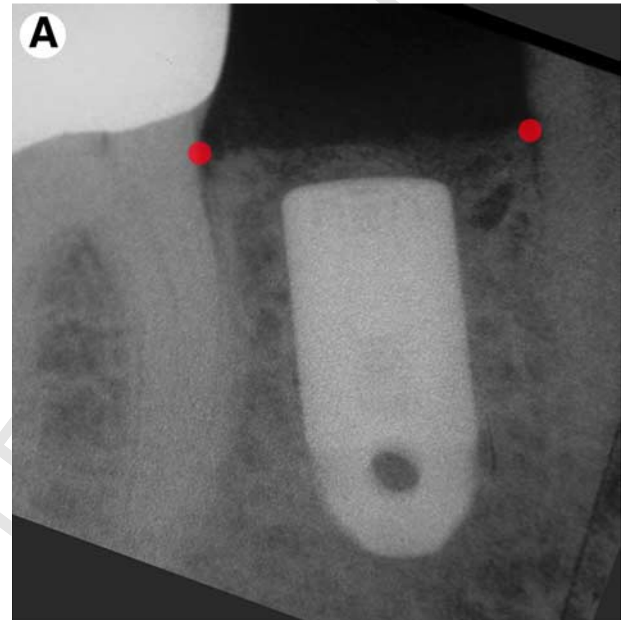
able result. The example used to illustrate this dilemma is depicted in Figure 27. The patient was self-referred after being informed that an extensive reconstruction to open her vertical dimension of occlusion was recommended after the implants had been placed. The patient denied any preexisting knowledge of this and indicated that there had been limited interaction between the restorative doctor and the implant surgeon. Implant placement was ideal as to inter-implant distance, axis, and angulation (Fig 27). The existing dentition indicated extensive wear and attrition, with a slight Class III tendency and heavy anterior contact. Mounted cast indicated that retention would be an issue due to the limited space. The patient was sensitive to having occlusal access holes present, which added to the treatment dilemma. She also dismissed having a complete restoration of her occlusal relationship at that time. A complete diagnostic and treatment workup would have benefited the surgeon and the restorative dentist before the placement of the implants. The end point was that they lost an excellent patient. The implants were restored to her satisfaction after a considerable restorative effort.



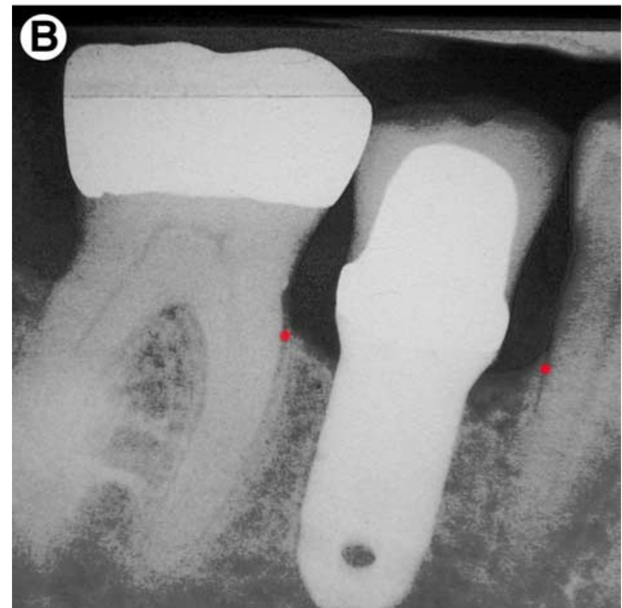


FIGURE 22. *A*, Posterior implant inserted below the crestal area of the adjacent teeth. *B*, At uncovering, several millimeters of bone had to be removed in order to seat impression coping and abutment. Consequently, the adjacent teeth lost bone support.

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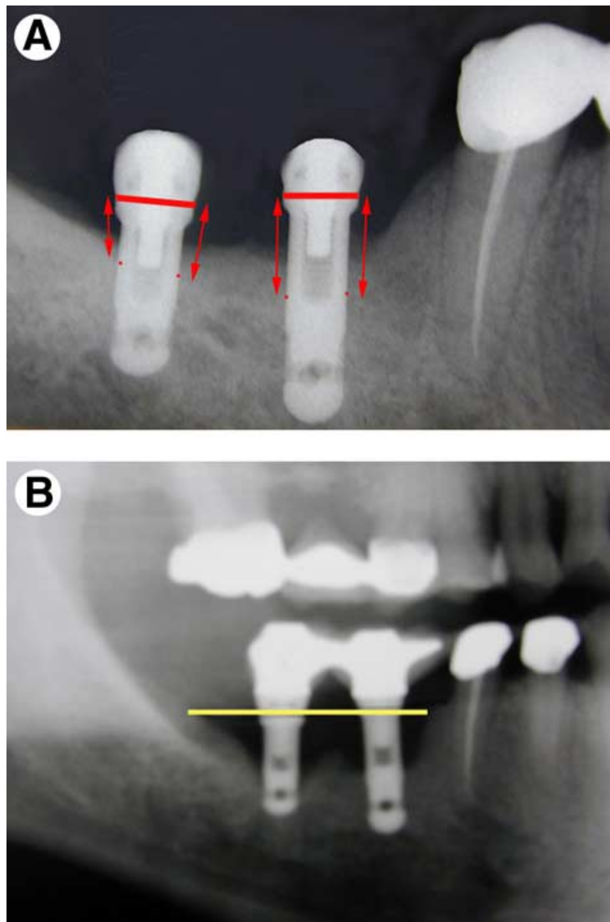

FIGURE 23. *A*, Example of implant not seated deep into the mandible. Both implants were 40% to 50% outside the bone matrix. *B*, Provisional loading resulted in more bone loss and ultimate failure.

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Angulation

Improper implant angulation is the greatest challenge and the most problematic challenge for the restorative dentist.[31-36] This problem is not limited to complex multi-implant combination treatment plans. Treatment plans involving one or two implants often demonstrate a lack or loss of anatomic orientation (Fig 28). In the example illustrated, the implant was placed in the correct location with the exception of the 30 degree buccal angulation. This resulted in fabrication of a custom abutment, with additional laboratory expenses and compromised loading. Even minor angulation changes can impact the restorative outcome as illustrated in the second case involving two implants and an over denture (Fig 29). The slight divergence of the implants restored with ball attachments resulted in a problematic path of insertion and required modification of the head of the ball attachment. This resulted in a higher maintenance profile for the patient who has had to have the O rings replaced at more frequent intervals.

Two other examples illustrate complete loss of orientation in the edentulous mandible (Fig 30). The resulting implants were placed at 35 to 40 degrees of angulation to the correct angulation. In the one case it resulted in the fracture of the implant body and in the second, a significantly compromised overdenture design.

IMPLANTS MAY BE ANGLED ACCORDING TO THE LEFT OR RIGHT HANDEDNESS OF THE CLINICIAN

The case in Figure 31 illustrates a bilaterally grafted patient with a more than adequate bone bed in which to place implants. Eight implants were placed, all of which were off angled to the left. The implants were 25 to 40 degrees off axis angulation, when in all sites the implants could have been placed vertically in parallel. This resulted in a restorative design challenge, extra laboratory expenses, and more restorative chair time.

Inappropriate angulation leads to multiple complications, and most often significant restorative difficulties. This is well documented with two posterior partially edentulous cases. In the first case, two implants were each placed by two different surgeons at different times. The cuspid and bicuspid implants were placed first with ideal spacing and angulation. Subsequently two additional implants were placed to replace the molars. These were placed to the lingual and at 40 degree angulation (Fig 32). Restoring these required custom abutments. The emergence profile was also compromised because they were not inserted deep enough (Fig 33).

In the second example, 3 implants were placed initially in a grafted site, one of which compromised the right cuspid (encroachment) (Fig 34). An additional implant was placed in the cuspid site and the implants were restored. The patient, who had experienced chronic discomfort for several months and was displeased with the esthetic result, self-referred to this author. Radiographs indicated multiple problems: sinus perforation, severe implant angulation (35 degrees), and considerable bone loss (Fig 35). The bone loss was attributed to angulation overload and insufficient initial grafting. The implants in site 3, 4, and 5 were removed and the area was re-grafted. Three implants were placed at 17 degree angulation and subsequently restored (Fig 36). The end result was an increased time line of more than 12 months and a major re-treatment expense.

Improper angulation in the esthetic zone with severe facial off axis orientation can result in severely compromised clinical crown contours. As seen in Figure 37, two implants were placed immediately after tooth extraction, replacing tooth numbers six

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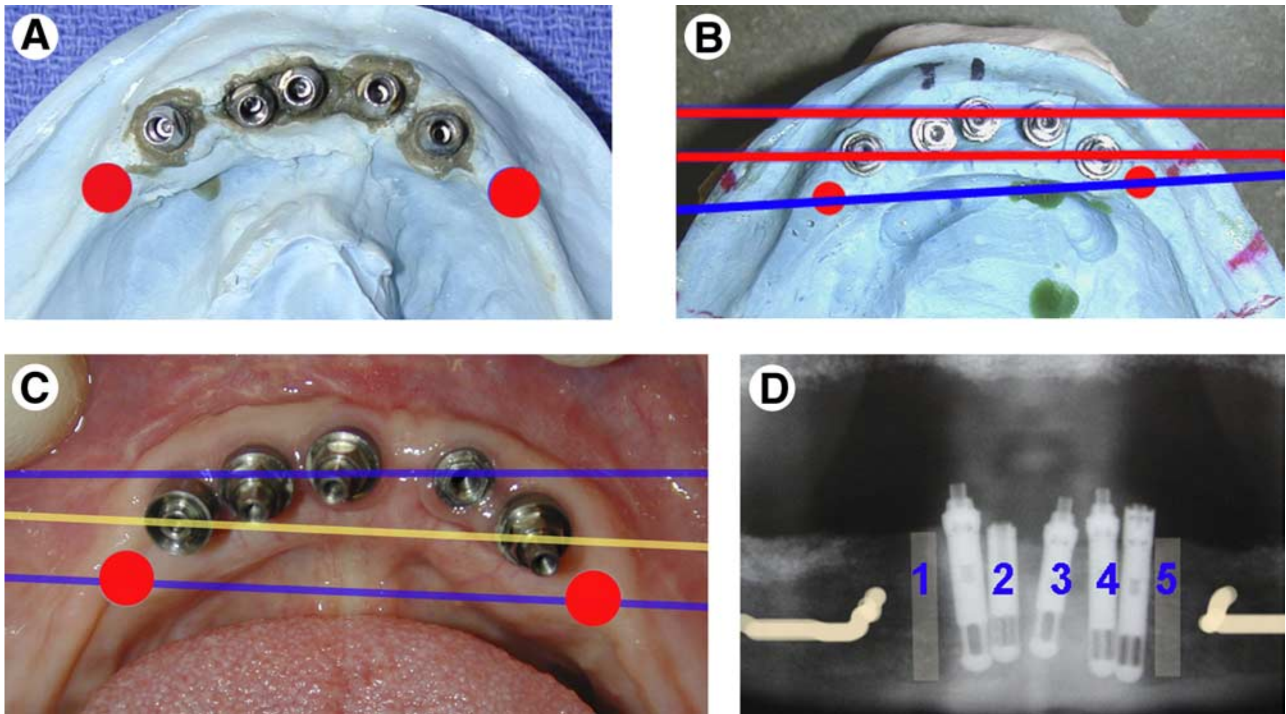

FIGURE 24. *A*, Implants placed in nearly straight line. Radiographs indicated that the implants could have been placed further distally. *B*, The anterior-posterior (A/P) spread would have been double had the implants been located in the more distal site. Implants could have spaced more ideally and crowding could have been avoided. *C*, Another case where the A/P spread could have been significantly improved. *D*, Radiograph indicates what the proper spacing of the implants should have been.

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and eight. At second stage it was obvious that the implants had been placed too far to the labial and at angles exceeding 45 degrees (Fig 37). Temporary cylinders were placed on the master cast and a wax-up was completed to determine the projected contours (Fig 38). It was apparent that the resulting clinical crowns and pontic area would be much longer than the adjacent natural teeth. The patient was given the option to have the implants removed and the area retreated. Because of the extended additional time line and more surgery she declined. The end result was a severe esthetic compromise along with long-term biomechanical and component challenges (Fig 39). What could have been a routine restorative case turned into an extended series of complications with custom abutments, extensive additional chair time, several reapplications of porcelain and increased laboratory costs.

The mechanical and biomechanical complications related to adverse angulation to load cannot be understated. Angulation to load of 15 to 20 degrees leads to "some difficulties" and angulation of 30 degrees or more leads to "substantial difficulties."[39] The complications reported are loose screws, fractured screws, bone loss, implant fracture and the loss of integration. The previous clinical cases exemplify some of those complications. More graphic from an economic im-

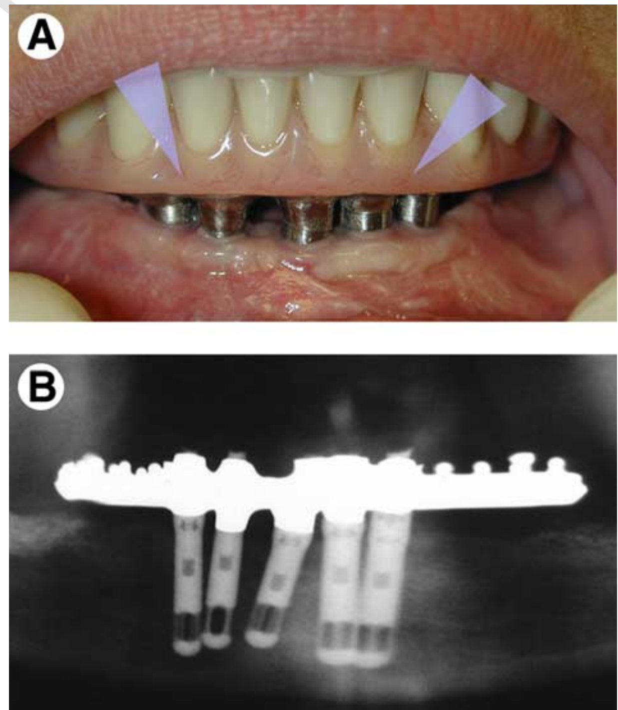

FIGURE 25. *A*, Inadequate spacing resulting from implants not placed perpendicular to each other. The axial orientation resulted in near contact of the cervical areas of the implant. *B*, As a consequence, hygiene access was extremely difficult to manage even with hourglass modified abutment contours between the most distal implants.

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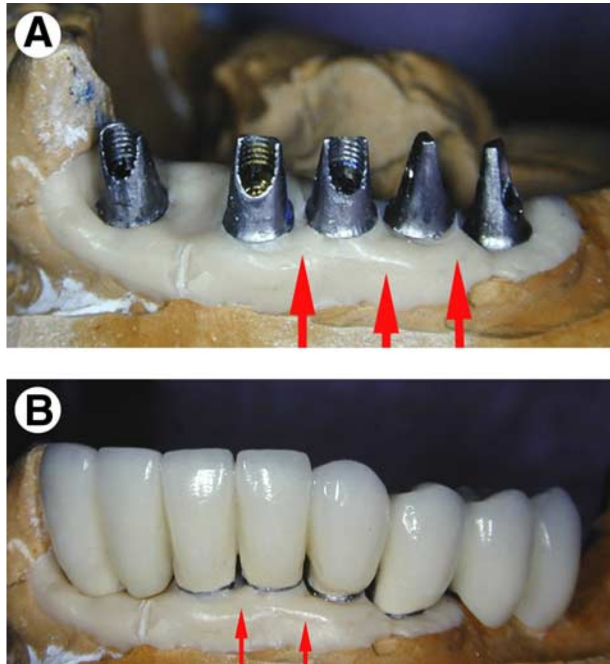

FIGURE 26. *A*, Partially edentulous case where implants were placed too close together. The abutments could not be reduced proximally any further. *B*, Distance of less than 3 mm resulted in compression of the interproximal tissue leading to eventual apical migration. Cervical embrasures were inadequate for optimal access.

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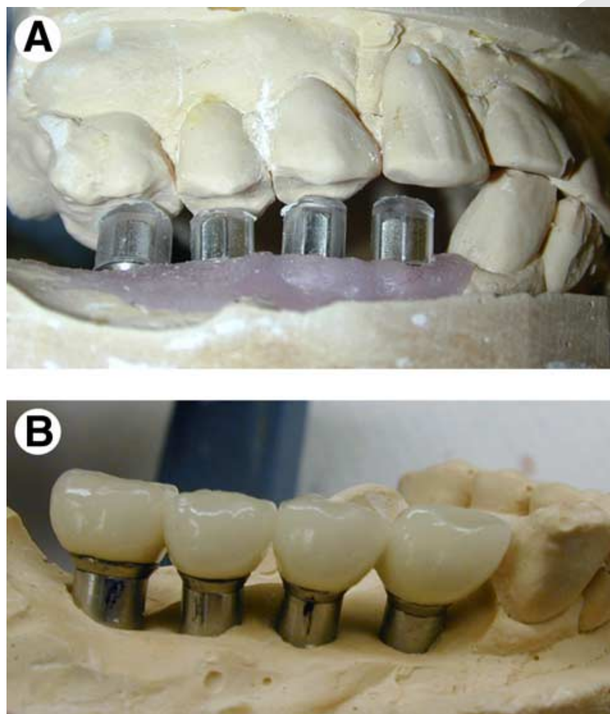

FIGURE 27. *A*, Inadequate intra-arch space in a patient that should have had a more extensive treatment plan, including opening her vertical dimension of occlusion, resulted in abnormally short bulbous crown contours (*B*).

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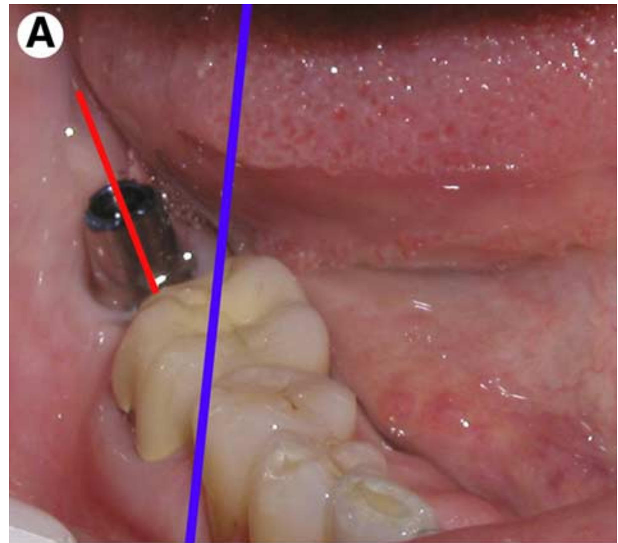

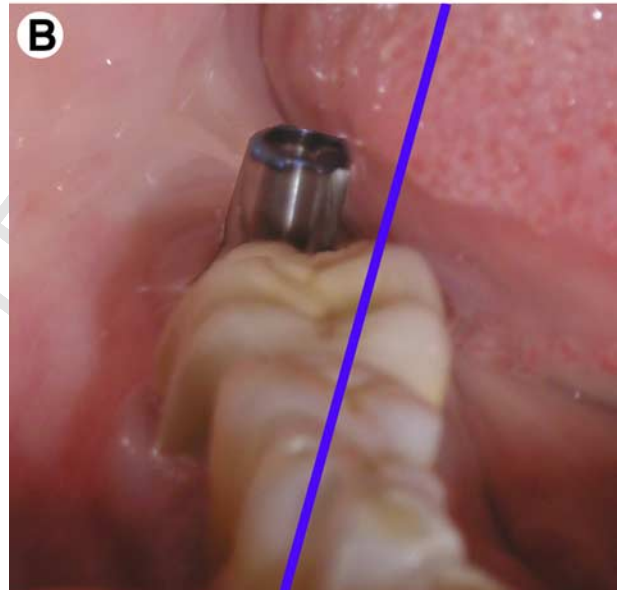

FIGURE 28. *A*, Implant placed with angulation that does not correspond (*red line*) to natural tooth orientation and occlusal loading axis (*blue line*). *B*, Blue line shows the correct angulation for a mandibular molar. The neurovascular canal was not an issue in this case.

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pact was the report by Rubenstein and Taylor where they followed a patient for 10 years with severely buccally angled implants.[40] During that time there were 24 screw fractures, approximately 2 screws every 7 months. The author conservatively assessed a cost of $4,000 in chair time, lost production, assistant and office staff expense as well as the replacement parts and supplies. Since the restorative doctor did not place the implants, whose responsibility is it to maintain and absorb those additional costs? An even greater loss however is the loss of confidence of the restorative doctor and patient and its long-term impact on future implant cases.

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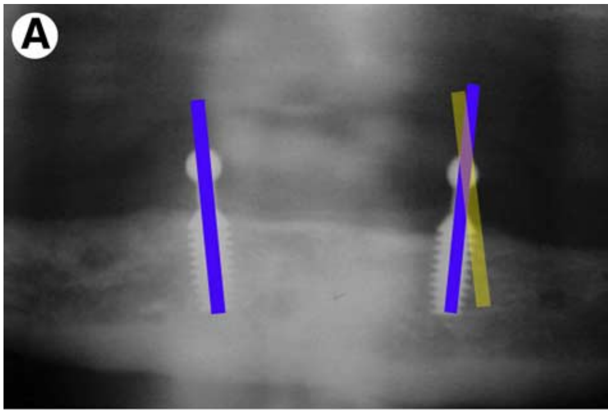

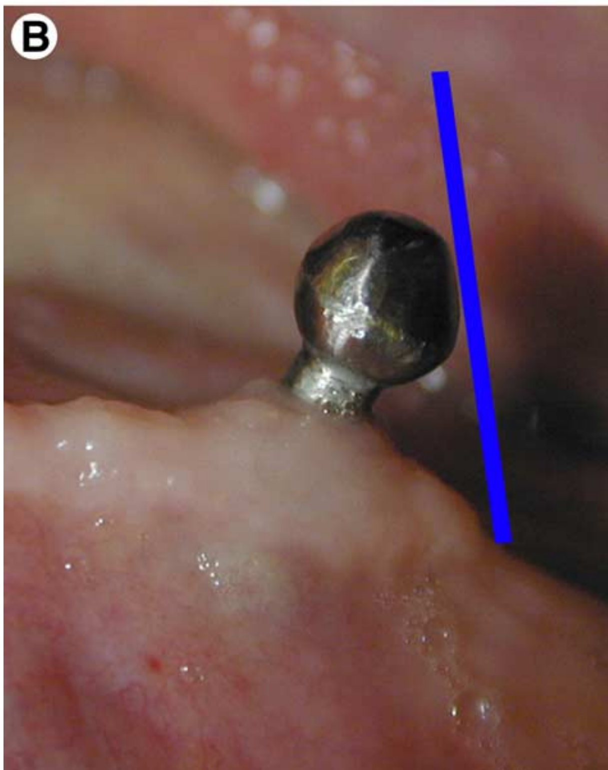

FIGURE 29. *A*, Placement where the implants are slightly divergent (*blue lines*). Because this is a press fit implant/abutment interface, abutment angulation changes (yellow line) are not easily made. *B*, The problematic path (*blue line*) of insertion and removal created by the divergence resulted in having to modify the head of the ball attachment.

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Inadequate Spacing

To appreciate the profound impact that minor surgical placement deviation can have on the restorative aspects of a case, this last case is explored. The patient was referred after the implants had been placed. The original restorative doctor had not completed a full implant workup on the patient and did not supply the surgeon with a surgical stent or a cast indicating the desired locations of the implants. The surgeon

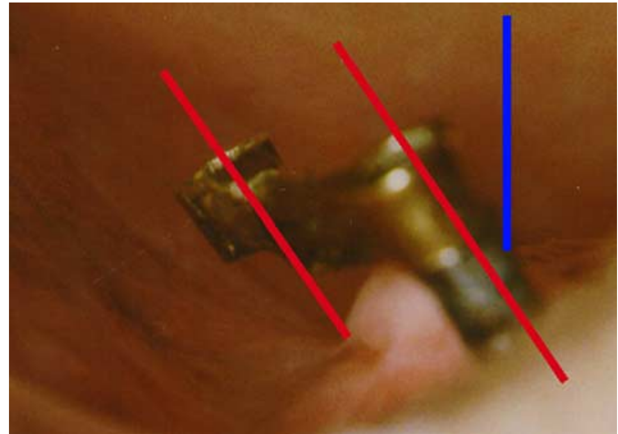

FIGURE 30. *A*, Loss of orientation resulted in the severe facial angulation (*red lines*) of these 2 implants. The overdenture had a large concavity (food trap; *blue line*) along the facial flange in order to accommodate the improper location and permit insertion. *B*, Functional loading resulted in implant fracture. Patient declined any additional treatment effort with implants. *C*, Another example of severe facial angulation. The red dots indicate the ridge crest where the implants should have been located. Tissue bar design was modified to allow anterior-posterior rotation and minimize excessive loads to the implants. *D*, Connector arm areas had to be relieved in the denture base, and resulted in some food impaction in the void.

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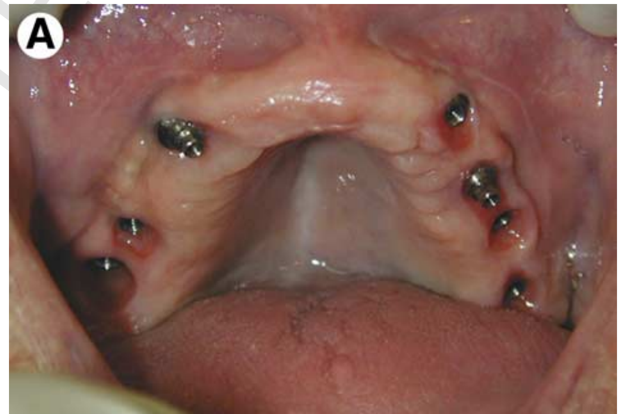

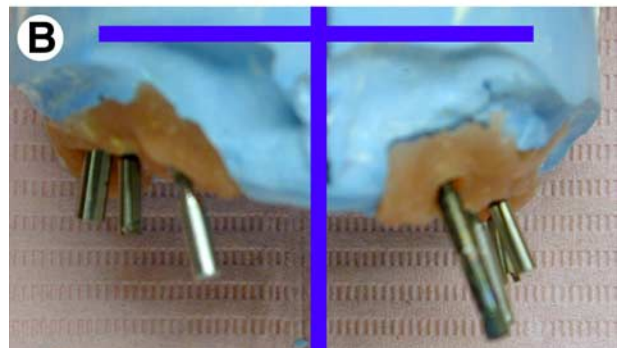

FIGURE 31. Disorientation in the maxilla. *A*, Implants placed by a right-handed surgeon. *B*, Guide pins in place to illustrate the inappropriate angulation. This was a bilaterally grafted case and the bone base was perfect. In the anterior right area, two of the implants contacted, resulting in the loss of one implant.

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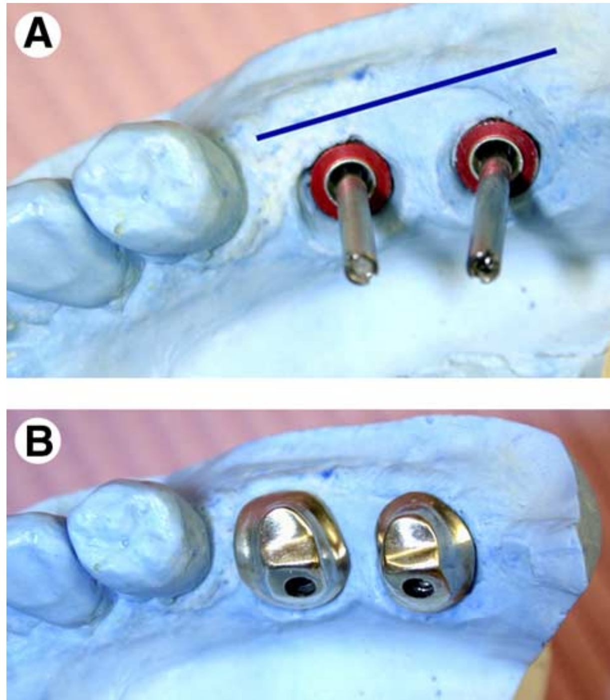

FIGURE 32. *A*, Two implants located with angulation to the lingual and not in alignment with the previously placed implants or normal axial inclination of the dentition. *B*, Custom abutments, in place to receive single crowns.

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estimated the locations of the implants and completed the surgery (Fig 40). The patient presented with failing temporaries immediately prior to second stage. Impressions were made, mounted and a full mouth wax-up completed (Fig 41). New provisional restorations were placed and the projected esthetic results were then presented to the patient. The locations and spacing of the left mandibular implants were excellent. Normal crown contours were easily attainable (Fig 42). The right mandibular implants were evenly distributed in the edentulous segment however two of the three were outside the confines of normal clinical crown contours. The most anterior implant was located directly in the interproximal space (Fig 43 *A*, *B*). The resulting restoration was severely compromised. Each of the maxillary edentulous areas had two implants placed. In both instances these were placed equidistant to the adjacent teeth and to each other (Fig 44 *A*, *B*). The resulting bridge segments had constricted and abnormal pontic contours with minimal embrasures (Fig 44 *C*, *D*). In 7 out of the 9 implants placed, a few millimeters change in spacing would have made the difference from a problematic result to perfection. Fortunately, after major restorative efforts, the patient's expectations were realized (Fig 44 *E*).

The responsibility for the incorrect spacing in this case is equally shared by the original restorative dentist and the surgeon. When a restorative dentist is devoid of adequate experience and knowledge and fails to meet the required responsibilities to carry an implant case to completion, it is incumbent on the

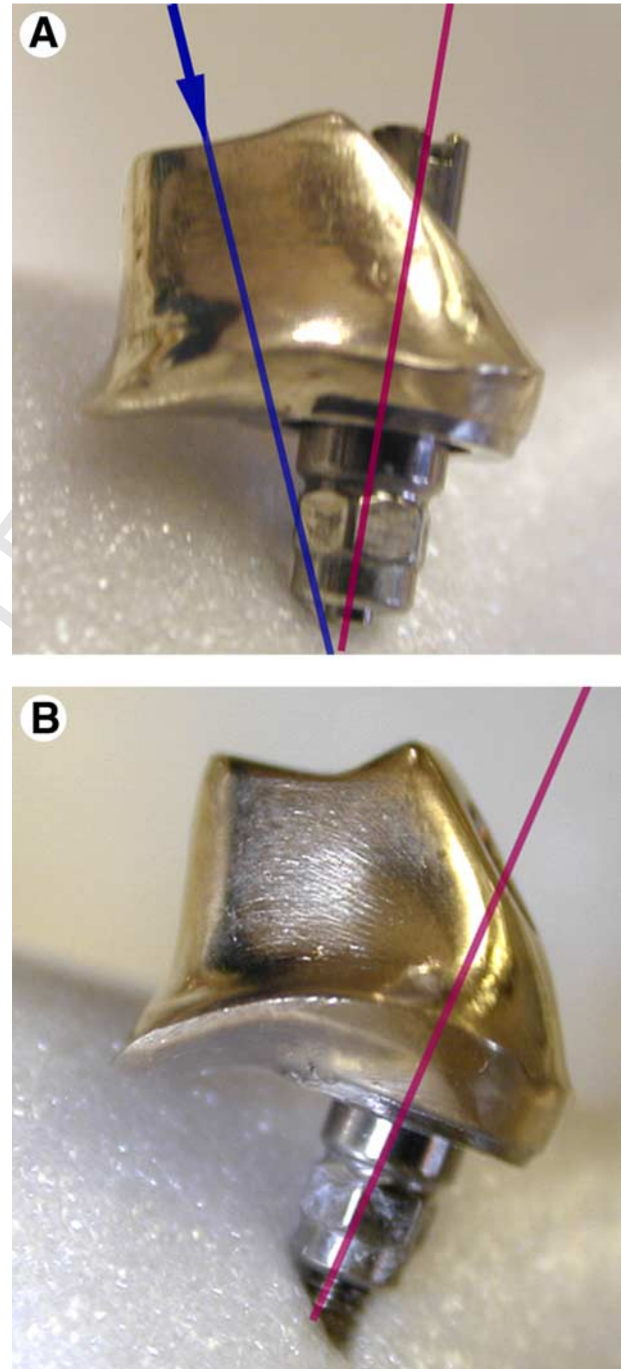

FIGURE 33. Implants were not placed deep resulting in a compromised emergence profile (*A*, *B*; *red lines*). The angulation discrepancy is easily visualized (*A*, *blue line*).

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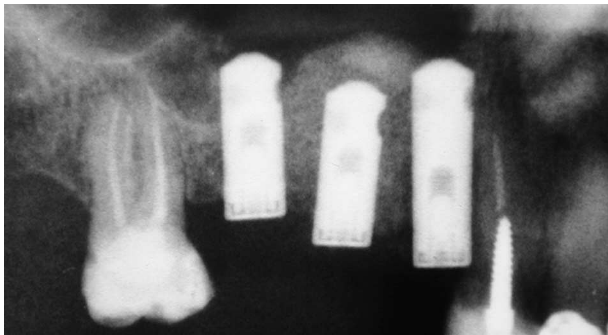

FIGURE 34. Original 3 implants showed sinus perforation and root encroachment. Implants were placed after a sinus augmentation.

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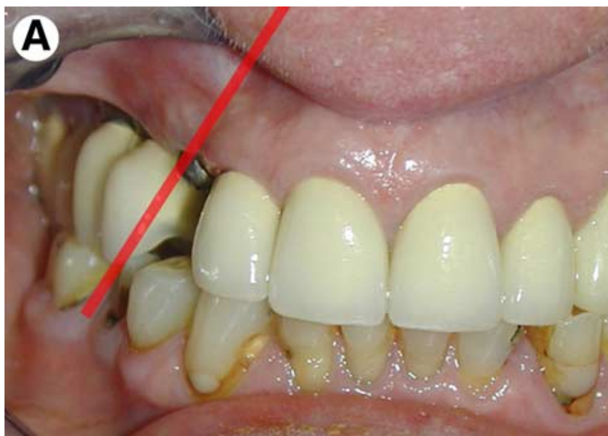
surgeon to get an implant workup by another restorative dentist prior to placing the implants, if for no other reason than to insure that the surgical part of the treatment is successful.



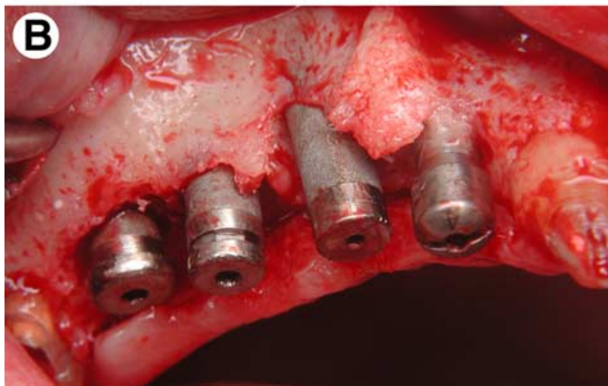


FIGURE 35. Clinical condition at the time the implants were removed and the segment regrafted. *A*, Initial restoration with 35-degree angulation (*red line*) and bulbous cervical contours. *B*, Radiographs showed progressive bone loss, attributed to angulation overload.

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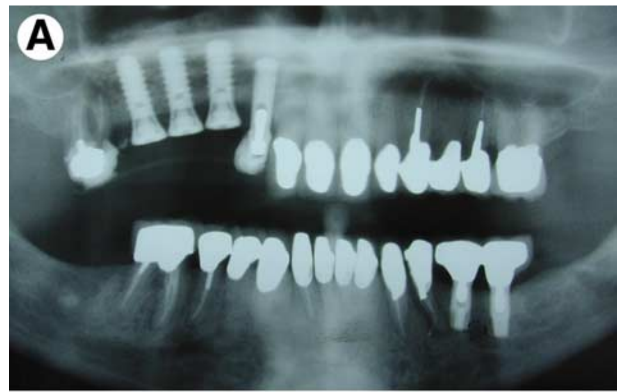

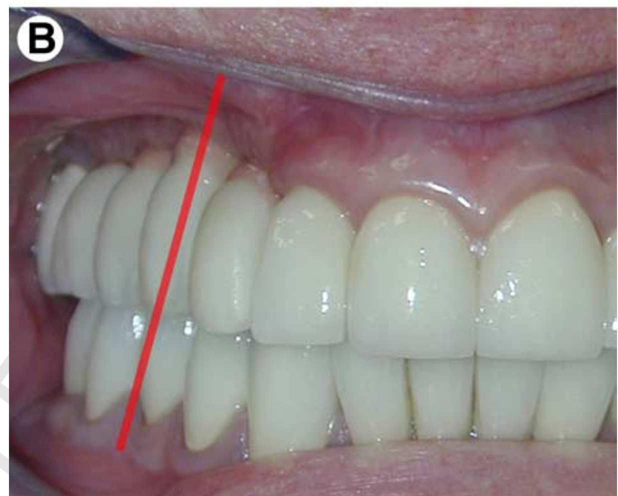

FIGURE 36. *A*, Radiograph of new implants in place with near parallel alignment. Once the implants were integrated, the number 2 molar that had been used as a temporary abutment for a provisional bridge was extracted. *B*, The entire dentition was retreated and new crowns were placed on the implants. The corrected angulation was 17 degrees (*red line*). The resulting emergence profile and cervical contour was dramatically improved.

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Summary

It is critical to have an accurate understanding of the educational limitations of dentists because of a lack of formal training with implants. It is not a unilateral problem, as can be easily discerned from the cases illustrated in this article. The team must pay attention to specific direction as to the number, location, depth, angulation, spacing, and distribution of implants in their patients. As a consequence, more and more experienced restorative dentists are incorporating implant treatment in their practice. There is more awareness and concern at having simple restorative cases turn into very complex undertakings that require extra chair time and additional laboratory expenses. To avoid treatment planning complications and surgical miscues the following is recommended: *1*) Always complete a detailed restorative and surgical

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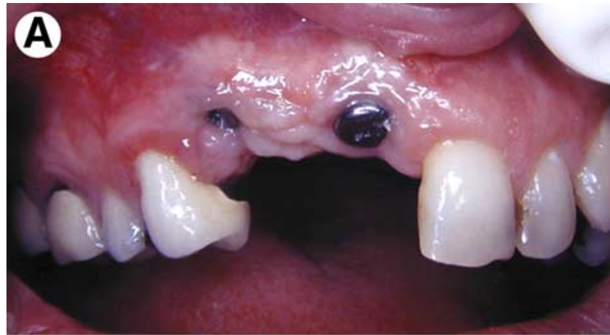

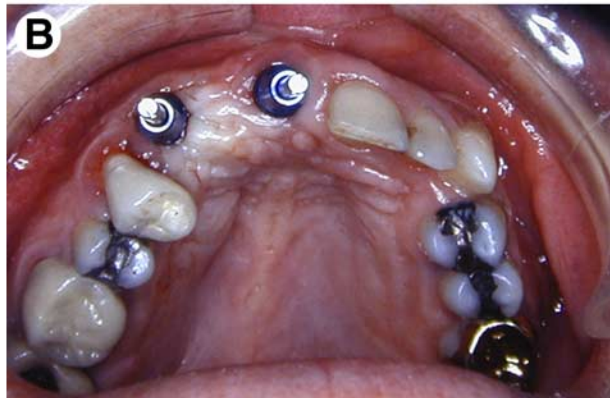

FIGURE 37. *A,* Incorrect angulation of implants in the esthetic zone. Photo was taken after several attempts had been made to improve the soft tissue coverage. *B,* Angulation of implants was totally out of harmony with the adjacent natural teeth. Discrepancy exceeded 45 degrees.

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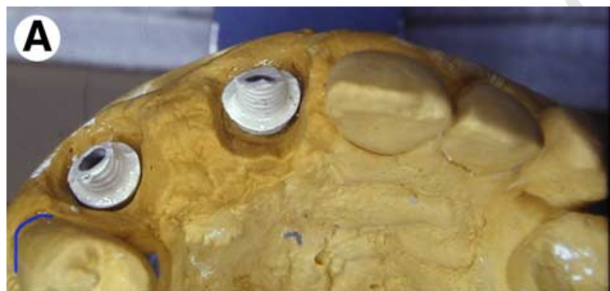

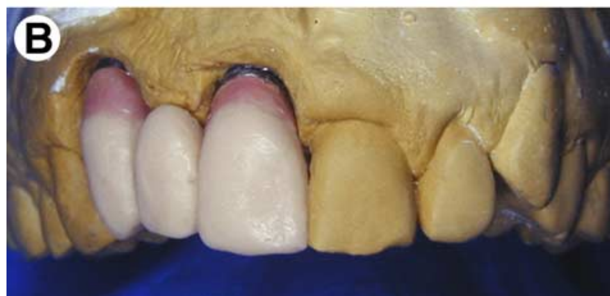

FIGURE 38. *A,* Temporary cylinders in place with the facial aspect removed to visualize the incisal orientation. *B,* Diagnostic wax-up to evaluate crown morphology and probable esthetic result. Crown length was significantly different than the adjacent natural teeth. Cervical pink wax was used in an effort to reduce the dramatic difference in crown length.

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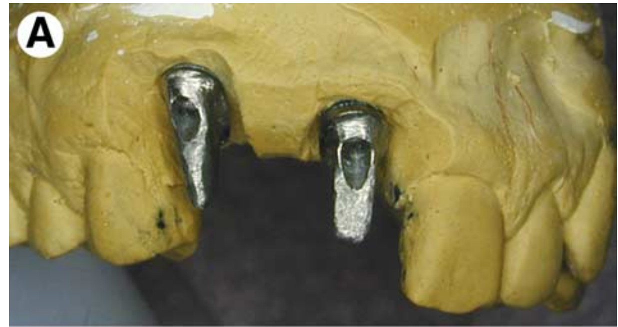

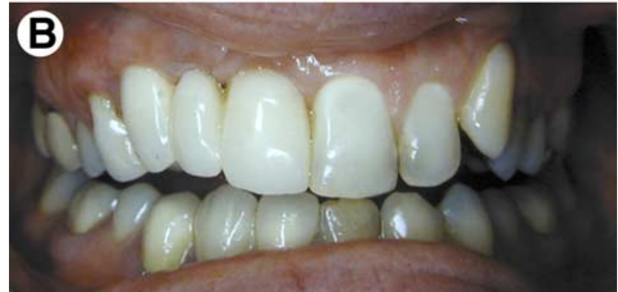

FIGURE 39. *A,* Custom milled abutments were hallow-ground on the facial to reduce the thickness of the porcelain-fused-to-metal bridge. *B,* Definitive bridge in place. Numerous ceramic modifications and try-in appointments were necessary to meet the patient's esthetic expectations.

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examination; *2*) Do not place implants without a restorative prosthodontic workup; *3*) Refer the patient to an experienced dentist for the workup; *4*) Insist on a diagnostic wax-up; *5*) Insist on a radiographic and a surgical stent and use it during placement; *6*) Determine that the entire treatment team has the knowledge and experience to complete the case; *7*) As a surgeon, be sure you understand the exigencies of fixed and removable restorative care; *8*) Make sure that team members have the same treat-

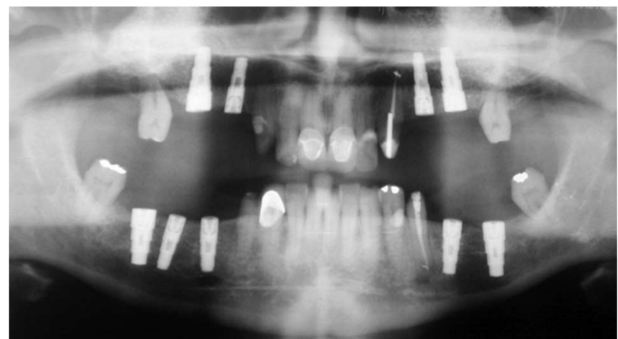

FIGURE 40. Radiograph of the implants in situ during initial examination.

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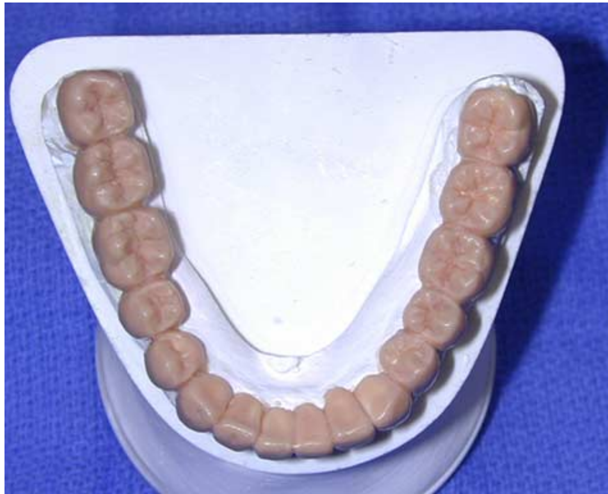

FIGURE 41. Diagnostic wax-up of the mandibular arch (after the implants had been placed). This gave a clear indication of the special problems inherent on the right posterior quadrant.

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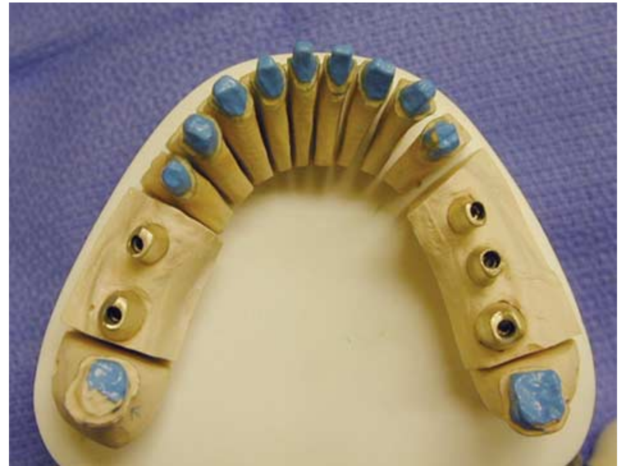

FIGURE 42. Lower arch working cast with abutments in place. Right segment shows the equidistant location of the 3 implants.

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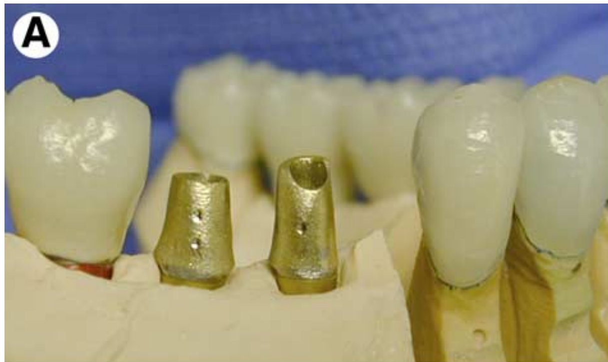

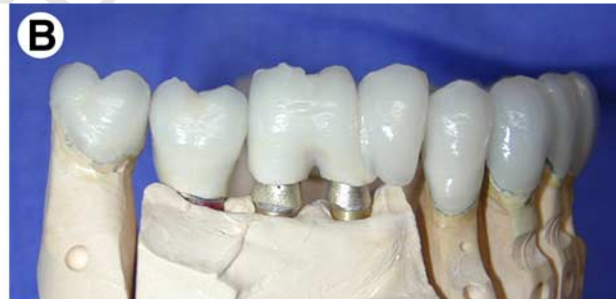

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FIGURE 43. *A*, The most distal implant in the right segment was well in the clinical crown contour of the second molar. The remaining 2 implants were not in the clinical crown confines of the first molar and bicuspid. *B*, Dramatic modification of the crown contour to accommodate the spacing miscue. *C*, Intaglio surface of the bridge segment clearly shows the aberrant crown contours necessary to restore the implants.

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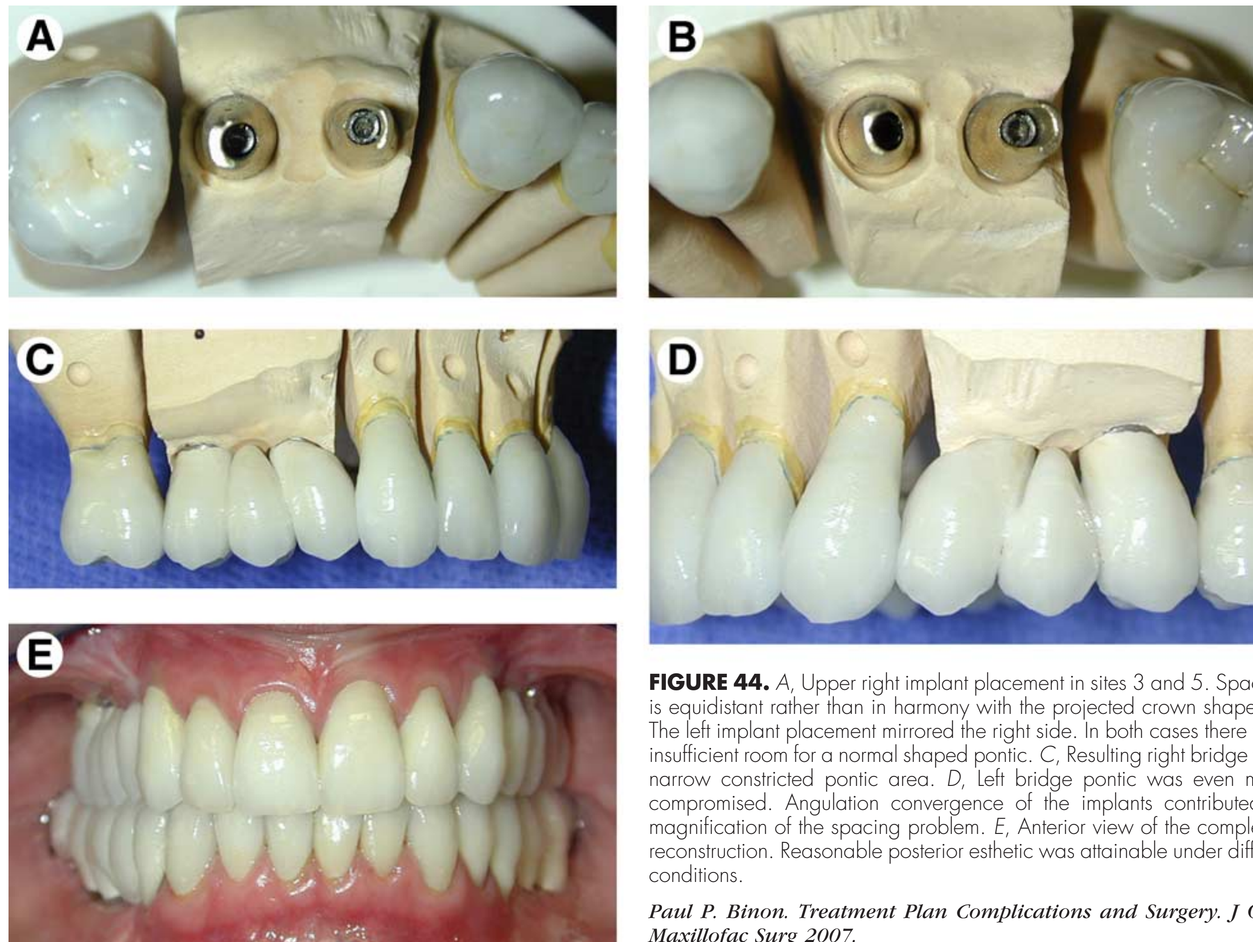

FIGURE 44. *A*, Upper right implant placement in sites 3 and 5. Spacing is equidistant rather than in harmony with the projected crown shape. *B*, The left implant placement mirrored the right side. In both cases there was insufficient room for a normal shaped pontic. *C*, Resulting right bridge with narrow constricted pontic area. *D*, Left bridge pontic was even more compromised. Angulation convergence of the implants contributed to magnification of the spacing problem. *E*, Anterior view of the completed reconstruction. Reasonable posterior esthetic was attainable under difficult conditions.

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ment vision; and *9*) Communicate. Never take anything for granted. Communicate.

References

1. Chacon GE, Bower DL, Larsen PE, McGlumphy EA, Beck FM: Heat production by 3 implant drill systems after repeated drilling and sterilization. J Oral Maxillofac Surg 64:265, 2006
2. Grassi S, Piattelli A, de Figueiredo LC, et al: Histologic evaluation of early human bone response to different implant surfaces. J Periodontol 77:1736, 2006
3. Shibli JA, Grassi S, de Figueiredo LC, et al: Influence of implant surface topography on early osseointegration: A histological study in human jaws. J Biomed Mater Res B Appl Biomater 80:377, 2007
4. Wittwer G, Adeyemo WL, Schicho K, Gigovic N, Turhani D, Enislidis G: Computer-guided flapless transmucosal implant placement in the mandible: A new combination of two innovative techniques. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 101:718, 2006
5. Becker W, Goldstein M, Becker BE, Sennerby L: Minimally invasive flapless implant surgery: A prospective multicenter study. Clin Implant Dent Relat Res 7:S21, 2005
6. Pikos MA: Atrophic posterior maxilla and mandible: Alveolar ridge reconstruction with mandibular block autografts. Alpha Omegan 98:34, 2005
7. Petrungaro PS, Amar S: Localized ridge augmentation with allogenic block grafts prior to implant placement: Case reports and histologic evaluations. Implant Dent 14:139, 2005
8. Block MS, Baughman DG: Reconstruction of severe anterior maxillary defects using distraction osteogenesis, bone grafts, and implants. J Oral Maxillofac Surg 63:291, 2005
9. Seol YJ, Park YJ, Lee SC, et al: Enhanced osteogenic promotion around dental implants with synthetic binding motif mimicking bone morphogenetic protein (BMP)-2. J Biomed Mater Res A 77:599, 2006
10. Mannai C: Early implant loading in severely resorbed maxilla using xenograft, autograft, and platelet-rich plasma in 97 patients. J Oral Maxillofac Surg 64:1420, 2006
11. Finger IM, Castellon P, Block M, Elian N: The evolution of external and internal implant/abutment connections.Pract Proced Aesthet Dent 15:625, 2003
12. Mollersten L, Lockowandt P, Linden LA: Comparison of strength and failure mode of seven implant systems: An in vitro test. J Prosthet Dent 78:582, 1997
13. Ganz SD: Conventional CT and cone beam CT for improved dental diagnostics and implant planning. Dent Implantol Update 16:89, 2005
14. Verstreken K, Van Cleynenbreugel J, Marchal G, van Steenberghe D, Suetens P: Computer-assisted planning of oral implant surgery. An approach using virtual reality. Stud Health Technol Inform 29:423, 1996
15. Jivraj SA, Corrado P, Chee WW: An interdisciplinary approach to treatment planning in implant dentistry. J Calif Dent Assoc 33:293, 2005
16. Garg AK: Complications associated with implant surgical procedures part II: Treatment. Dent Implantol Update 15:33, 2004
17. Winkler S, Morris HF, Ochi S: Implant survival to 36 months as related to length and diameter. Ann Periodontol 5:22, 2000
18. Binon PP: Implants and components: Entering the new millennium. Int J Oral Maxillofac Implants 15:76, 2000
19. Tagger-Green N, Horwitz J, Machtei EE, Peled M: Implant fracture: A complication of treatment with dental implants–review of the literature. Refuat Hapeh Vehashinayim 19:19, 2002

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20. Porter JA, von Fraunhofer JA: Success or failure of dental implants? A literature review with treatment considerations. Gen Dent 53:423, 2005
21. Karlsson U, Gotfredsen K, Olsson C: Single-tooth replacement by osseointegrated Astra Tech dental implants: A 2-year report. Int J Prosthodont 10:318, 1997
22. Henry PJ: A review of guidelines for implant rehabilitation of the edentulous maxilla. J Prosthet Dent 87:281, 2002
23. Cochran DL, Morton D, Weber HP: Consensus statements and recommended clinical procedures regarding loading protocols for endosseous dental implants. Int J Oral Maxillofac Implants 19 Suppl:109, 2004
24. Dario LJ, Aschaffenburg PH, English R Jr, Nager MC: Fixed implant rehabilitation of the edentulous maxilla: Clinical guidelines and case reports. Part II. Implant Dent 9:102, 2000
25. Morton D, Jaffin R, Weber HP: Immediate restoration and loading of dental implants: Clinical considerations and protocols. Int J Oral Maxillofac Implants 19 Suppl:103, 2004
26. Gastaldo JF, Cury PR, Sendyk WR: Effect of the vertical and horizontal distances between adjacent implants and between a tooth and an implant on the incidence of interproximal papilla. J Periodontol 75:1242, 2004
27. McAlarney ME, Stavropoulos DN: Theoretical cantilever lengths versus clinical variables in fifty-five clinical cases. J Prosthet Dent 83:332, 2000
28. McAlarney ME, Stavropoulos DN: Determination of cantilever length-anterior-posterior spread ratio assuming failure criteria to be the compromise of the prosthesis retaining screw-prosthesis joint. Int J Oral Maxillofac Implants 11:331, 1996
29. Tarnow DP, Cho SC, Wallace SS: The effect of inter-implant distance on the height of inter-implant bone crest. J Periodontol 71:546, 2000
30. Cardaropoli G, Wennstrom JL, Lekholm U: Peri-implant bone alterations in relation to inter-unit distances. A 3-year retrospective study. Clin Oral Implants Res 14:430, 2003
31. Walton JN, Huizinga SC, Peck CC: Implant angulation: A measurement technique, implant overdenture maintenance, and the influence of surgical experience. Int J Prosthodont 14:523, 2001
32. Lima Verde MA, Morgano SM, Hashem A: Technique to restore unfavorably inclined implants. J Prosthet Dent 71:359, 1994
33. Zinner ID, Panno FV, Abrahamson BD, Small SA: Prosthodontic solutions for compromised implant placement. Int J Prosthodont 6:270, 1993
34. Grossmann Y, Madjar D: Prosthetic treatment for severely misaligned implants: A clinical report. J Prosthet Dent 88:259, 2002
35. Kallus T, Henry P, Jemt T, Jorneus L: Clinical evaluation of angulated abutments for the Brånemark system: A pilot study. Int J Oral Maxillofac Implants 5:39, 1990
36. Goodacre CJ, Kan JY, Rungcharassaeng K: Clinical complications of osseointegrated implants. J Prosthet Dent 81:537, 1999
37. Tinsley D, Watson CJ, Preston AJ: Implant complications and failures: The fixed prosthesis. Dent Update 29:456, 2002
38. Khadivi V: Correcting a nonparallel implant abutment for a mandibular overdenture retained by two implants: A clinical report. J Prosthet Dent 92:216, 2004
39. Beumer J. Personal communication.
40. Rubenstein JE, Taylor TD: Apical nerve transection resulting from implant placement: A 10-year follow-up report. J Prosthet Dent 78:537, 1997

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AUTHOR QUERIES

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AQ31— Edit OK?

AQ32— PFM meaning porcelain-fused-to-metal here, and in legend for figures 14 and 39A?

AQ33— Please note journal style: do not reference teeth by number, rather, use words; and, use 'after' instead of 'following.' Please confirm meaning retained in edited sentence.

AQ34— Edit OK?

AQ35— Please confirm labels A and B in legend are used correctly to identify the corresponding panel of the illustration.

AQ36— Meaning retained in edited sentence?

AQ37— Edit OK?

AQ38— Edit OK?

AQ39— Please confirm meaning of red and blue lines is correct in legend.

AQ40— Please confirm meaning of yellow line and blue line in panel B is correct in legend.

AQ41— Please confirm meaning of red and blue lines shown in panel A are correct in legend.

AQ42— Please provide art for figure 30, panels B, C, and D and confirm in-text citation and legend are appropriate. Alternatively, delete unrelated text from legend.

AQ43— Panel A meant here?

AQ44— Edit OK?

AQ45— Legend revised per journal style and preference for use of the word, "show" instead of "demonstrate." Please confirm edit is OK and meaning of red line correctly indicated for panel A.

AQ46— Please confirm meaning of red line in panel A is correctly indicated.

AQ47— Figure legends should stand on their own. For clarity, "that" segment changed to "the right" segment. Please confirm edit is OK, or modify to indicate which segment is meant by "that" segment.

AQ48— Figures originally numbered 45 A and B and 46 have been incorporated as a continuation

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of figure 44, and are now labeled as panels C, D, and E (here, and in text).

AQ1— Please approve or modify short title for running head.

AQ2— Please note spelling change to use root of the word, 'cue,' meaning anything said or done that is followed by a specific action.

AQ3— Please add street address and postal code to correspondence address.

AQ49— AUTHOR: Is figure quality acceptable? Figure files received were low resolution.

AQ4— Per journal style, acronym must be spelled out then cited parenthetically at first use: Please confirm 'fixed partial denture' is correct for acronym FPD.

AQ5— Please confirm computed tomography meant for acronym CT, and meaning is correct in edited sentence (both CT imaging and computer-assisted TP software have revolutionized).

AQ6— 'fixed or removable' meant?

AQ7— Acronym TMJ means transmandibular joint?

AQ8— Sentence edit OK?

AQ9— Meaning retained in edited sentence?

AQ10— Please confirm spelling change is correct: 'immanent' (meaning 'remaining within, or inherent') changed to imminent, meaning 'likely to occur at any moment, or impending.'

AQ11— Please clarify; when referring to product by brand name, the name and location of manufacturer must also be specified.

AQ12— possessive cupids' changed to plural cupids here, OK?

AQ13— Edit OK for indication of tooth number ?

AQ14— Edit OK for indication of teeth #'s?

AQ15— Please note journal preference for the term 'use' instead of 'utilize.' Edit OK?

AQ16— Please confirm edited heading is OK. Also, please note per journal style, first use and definition of acronym AP has been taken out of heading.

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AQ17— Meant?

AQ18— Meant?

AQ19— Please confirm meaning retained in edited sentence.

AQ20— Meaning retained in edited sentence?

AQ21— Please confirm 'loss of integration' meant.

AQ22— Edited sentence OK?

AQ23— e-pub reference updated to print-published report, OK?

AQ24— Please cite sequentially in text or delete from list and renumber remaining references and corresponding text citations.

AQ25— Please cite sequentially in text or delete from list and renumber remaining references and corresponding text citations.

AQ26— Please cite sequentially in text or delete from list and renumber remaining references and corresponding text citations.

AQ27— Please cite sequentially in text or delete from list and renumber remaining references and corresponding text citations.

AQ28— Personal communications are not allowed as references; please update this reference with published report, or, 1) delete from reference list and cite parenthetically in text including year of communication, and 2) renumber references as appropriate in text and in reference list.

AQ29— Please confirm labels A and B in legend are used correctly to identify the corresponding panel of the illustration.

AQ30— Please confirm labels A, B, and C in legend are used correctly to identify the corresponding panel of the illustration.