

Off-Axis Implant placement for anatomical considerations using the Co-Axis Implant

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Implants placed at positions off the vertical axis have been referred to as “tilted implants” or “off-axis fixtures.” These may be placed to avoid various anatomical structures or to eliminate the need for bone grafting and nerve repositioning procedures.

A literature search conducted on the placement of off-axis implants found that by using both mathematical models¹⁻⁸ and mechanical⁹ testing, the off-axis loading will produce stress on the implant and surrounding bone. There has been speculation on the effects of these forces but the articles reviewed found them to be within the physiologic range.

Two animal studies^{10,11} showed no apparent long-term differences in hard or soft tissue results around non-axial implants, although one study¹¹ showed short-term differences in the healing mechanisms.

Although mathematical models, mechanical testing, and animal studies can provide useful information, long-term human clinical results are required to ensure a procedure is effective. There have been numerous studies and articles published regarding tilted implants in humans.

The literature also demonstrates that the wider the spread of the implants in the arch along the alveolar crest

is, the more beneficial the load distribution. The improved support gained when implants are spread more posteriorly has been reported.¹² Krekmanov et al recommended that posterior tilting of the distal implants in either arch may reduce cantilever length and as a consequence provide better load distribution.¹³

Implants placed off-axis usually require angle-corrected abutments. Eger et al¹⁴ concluded that implants placed at unfavorable angles may be restored with angled abutments without compromise of function or esthetics. Sethi et al published two articles^{15,16} following 3,100 angle corrected restorations over 10 years, and concluded that good esthetic and functional results can be achieved.

Maló et al¹⁷ used implants in the maxilla and mandible in a method similar to Krekmanov, except that most of these implants were immediately restored. At one year Malo concluded that this treatment modality was highly successful. Rosén et al¹⁸ followed implants in the maxilla for 8 to 12 years that were tilted to avoid grafting procedures. They concluded that this was a successful alternative procedure to more resource-demanding techniques involving bone grafting. Calandriello et al¹⁹ showed similar findings in a 1-year follow-up study. Krennmair et al²⁰ studied 62 patients with mandibular overdentures and analyzed the various angles of the implants for optimal restoration. They concluded that sagittal mandibular inclination should be attributed more importance than axial loading of implants. Aparicio et al followed fixed implant bridges supported by both axial and tilted implants for 21 to 87 months post-insertion and concluded that the use of tilted implants is an effective and safe alternative to the maxillary sinus floor augmentation procedure.²¹

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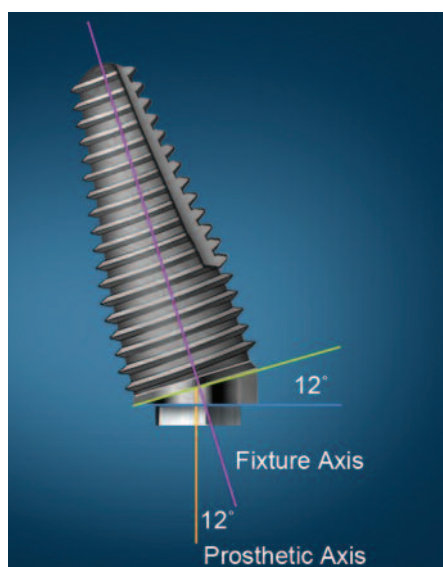


Figure 1: The Co-Axis implant illustrating the off-axis orientation of the platform in relation to the implant's long axis.



Figure 2: The Co-Axis implant with fixture mount that follows the implant's long axis. Orientation dimple on the fixture mount aids in orienting the direction of the off-axis platform.

The Co-Axis Implant

Use of tilted implants in the posterior may complicate the restorative aspects of treatment requiring custom abutments and forgoing the use of screw-retained prosthetics because of poor positioning. As a solution to prosthetic complications that have been associated with tilted implants, Southern Implants (Irvine, CA) introduced a threaded implant design with an off-axis correction within the implant platform in the European market 5 years ago after extensive testing. The Co-Axis implant was subsequently cleared by the FDA and has been available in the US market for over a year. This unique implant design permits positioning the restorative portion of the implant into a more favorable prosthetic position, allowing the tilted implants to have a restorative platform parallel to the other fixtures placed in the arch.

The Co-Axis implant was designed to overcome the anatomical constraints of the anterior maxilla, as implants placed in the maxillary anterior frequently have to be angled to keep the fixture within the triangle of bone. This usually requires the use of costly custom abutments to angle the prosthetics lingually to achieve esthetics. With screw access exiting the abutment on the facial, the practitioner is limited to cemented restorations. Thinning of the abutment facially to reduce bulk to accommodate the overlying crown may decrease the abutment strength or lead to esthetic issues with the final restoration.

The Co-Axis implant is available in the United States with

a 12° off-axis platform (Figure 1) with 4-mm, 5-mm, and 6-mm diameters and lengths of 8.5 mm, 10 mm, 11.5 mm, 13 mm, 15 mm, and 18 mm. A 24° off-axis correction is available in Europe on the 5-mm diameter fixtures. The implants have an external hex connector with a diameter of 2.7-mm and a height of 0.7-mm. The retaining screw in all of these implants is 2 mm (M2) with a standard thread. As the hex dimensions and retaining screw match on all three diameters of the Co-Axis, platform switching may be achieved on the 5-mm and 6-mm fixtures down to a 4-mm or 5-mm abutment. A fixture mount is included that follows the implant long axis and has a dimple that helps to orient the off-axis platform of the fixture during surgical placement (Figure 2).

Stress analysis using photoelastic studies comparing a load applied to an implant abutment 22° off the long axis in a standard straight implant and a Co-Axis implant found higher stress concentrations crestally on the standard fixture. The loads reported in the standard fixture were above the level needed to deform the fixture. Whereas in the Co-Axis fixture, the loads were found to be well below what is needed to create fixture deformation and endanger the fixture.²²

Howes et al reported a study of 225 Co-Axis fixtures placed in the anterior maxilla with 90% being immediately or early loaded and restored with a screw-retained prosthesis. The results showed a 99.11% success rate over the length of the study.²²



Figure 3: Co-Axis implants placed to avoid the sinus with implant long axis convergent.

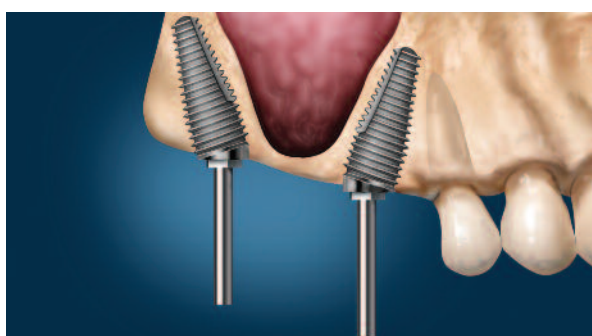


Figure 4: Parallelism of the prosthetic platform on the convergent Co-Axis implants placed to avoid the sinus.

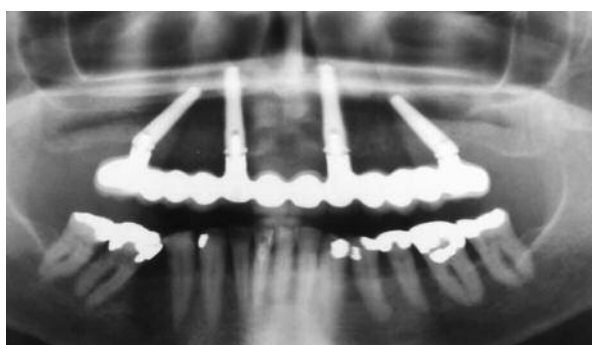


Figure 5: Panoramic radiograph showing distal angulation of the posterior implants placed to avoid the sinus. (Radiograph courtesy of Dr. Kent Yuen.)

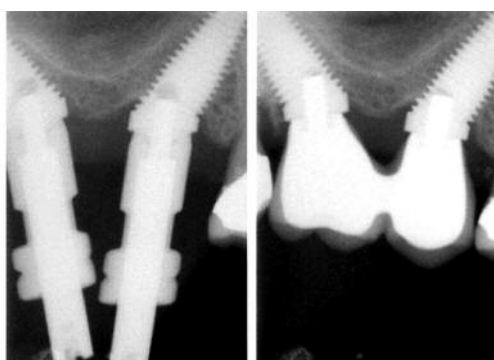


Figure 6: Convergent Co-Axis implants placed to avoid an enlarged maxillary sinus. (Figure courtesy of Dr. Kent Yuen.)

Surgical Placement

As with standard implant fixtures, a surgical guide is recommended to position the point where the implant will emerge from the crest in a buccal-lingual and mesial-distal orientation. A parallel hole is created in the study model and the angled directional indicator may be used to orient the access hole within the surgical guide at 12° matching the Co-Axis implant. The surgical guide is carried to the arch and an osteotomy is created in the osseous bed. The angled directional indicator is inserted into the osteotomy and the prosthetic axis is checked to parallel either other implant fixtures (ie, sinus or mental foramen avoidance) or the fixture screw access position (ie, anterior maxilla placement). When the orientation is confirmed, the site is enlarged to the diameter of the fixture to be placed.

Per the manufacturer's instructions, the fixture is threaded into the site using the handpiece connector on the fixture mount, rotating at a speed of 15 rpm to 20 rpm with a torque set at 30 Ncm. The implant is rotated to the desired position and the dimple on the fixture mount is oriented so that the angle correction is placed in the optimal position. If placement with the handpiece connector reaches 30 Ncm before the desired position occurs, a ratchet wrench is used to complete placement. The Co-Axis implant has a thread pitch of 0.6 mm, and for each full rotation of the implant the apical placement is less than 0.6 mm. If depth of placement is greater than three threads exposed supracrestally after the handpiece has reached 30 Ncm, it is recommended that the implant be removed and the site prepared to a greater depth and/or diameter.

If the fixture screw access orientation is uncertain, a 1.22 hex driver may be placed into the screw retaining the fixture mount, and the final orientation of the implant may be visualized.

After placement of the implants, the fixture mount is removed by placing a flat spanner on top of it to prevent rotation of the implant while the fixation screw is removed with a 1.22 hex driver. Once the fixation screw has been removed, the fixture mount is grasped with a forceps and tipped to remove it from the implant. A cover screw is placed with a 0.9 hex driver when a two-stage implant protocol is being used. Cover screws for the 4-mm diameter Co-Axis implant are shorter in length than a standard 4-mm implant cover screw, which cannot be used in this case as it will not fully seat.

Restoration of the Co-Axis implant follows usual prosthetic techniques after placement as the prosthetic platform is treated as a standard implant.

Avoidance of the Maxillary Sinus

Implants placed into the pterygomaxillary regions were

some of the first implants intentionally tilted, and they have been used for more than 15 years.²³ Pterygomaxillary implants often allow for the placement of implants in the posterior maxilla without the use of sinus augmentation procedures or other types of bone grafts. In the authors' experience, this decreases the cost of implant treatment, saves treatment time, and eliminates the need for cantilevers in many cases. Balshi et al²⁴ found the survival rate to be comparable to previous studies for implants placed in the maxillary arch. A subsequent study²⁵ by the same authors using surface-roughened implants in the pterygomaxillary region showed excellent clinical results. Valerón et al²⁶ followed pterygomaxillary implants for 5 to 10 years. They lost only two of 152 implants after functional loading and concluded that despite the necessity for inclination, these implants perfectly supported functional load. It should be noted that these implants are often placed into the worst quality bone and under the highest possible forces. The overwhelming majority of the implants in the above studies were 4 mm or less in diameter. All articles reviewed on these off-axis implants in the pterygomaxillary region appeared to endorse their use.

Enlargement of the maxillary sinus may complicate implant placement because of the angulations required to place implants if sinus augmentation is to be avoided. Mesial or distal tipping of a standard implant fixture bypassing the sinus prevents placement of a screw-retained prosthesis. This necessitates the fabrication of custom abutments in an attempt to achieve a parallel path of draw for the prosthesis.

The Co-Axis implant may be placed by tipping the posterior fixture mesially and the anterior fixture distally, straddling the enlarged sinus (Figure 3). The orientation dimples on the fixture mounts are rotated so that the implants achieve parallelism between the implant platforms. This permits the use of a screw-retained prosthesis with the screw access holes on the occlusal surface of the abutment crowns (Figure 4). If a cemented prosthesis is desired, often stock abutments may be used instead of custom abutments. This reduces the need for drastic angles to correct the orientation of standard implants.

The Co-Axis implant may permit orientation of the prosthetic platform more posteriorly by angling the posterior implants distally (Figure 5), thereby giving a full-arch prosthesis a wider base of support and minimizing posterior cantilevers. This may also be beneficial in situations where the sinus has enlarged in the area of the molars but sufficient bone is present in the posterior for implant placement into the pterygomaxillary region and an implant in the anterior region to be tipped distally, avoiding sinus augmentation (Figure 6).

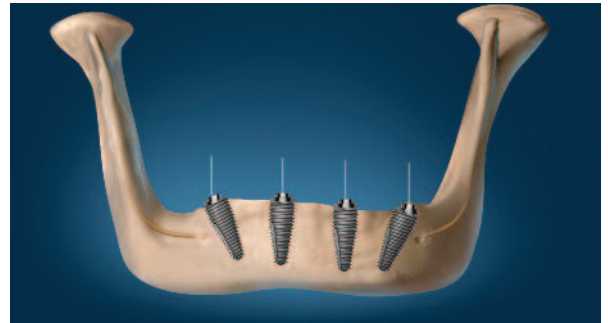


Figure 7: Illustration of the mandible with placement of Co-Axis implants in the distal positions to avoid the mental foramen and spread the support base of the implants. Note that although the implants are angled, the prosthetic platforms are parallel.

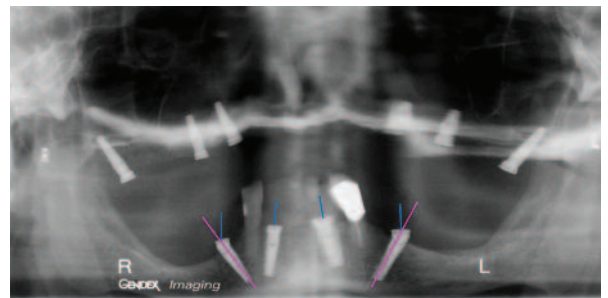


Figure 8: Panoramic radiograph showing Co-Axis implants placed in the distal sites bilaterally. The purple line indicates the long axis of the Co-Axis implants and the blue line indicates the prosthetic axis of the implants.

Avoidance of the Mental Foramen

Frequently, posterior teeth in the mandible are lost before the anterior teeth. This results in greater levels of resorption in the posterior and less bone superior to the mandibular canal for implant placement. Grafting alone seldom corrects this clinical situation and is unpredictable in achieving desired results; to place implants in the posterior and an inferior alveolar nerve repositioning may be necessary. With its post-surgical complications (ie, paresthesia), a nerve repositioning may not be elected by the patient. If parallel implants are placed in preparation for a full-arch prosthesis, the spread of the fixtures will be confined to the mesial of the mental foramen and require the elimination of second molars on the prosthesis or long cantilevers to accommodate occlusion to the first molars with a decrease in anterior-posterior spread.

If a tipped fixture is placed in the posterior with the implant platform superior to the mental foramen, the screw access hole will emerge at the distal aspect of the prosthesis, creating complications to the axis to the prosthetic head. A custom abutment may be used but the severe angulation required of the abutment head can create undercuts that result in food traps or areas that are difficult to maintain.

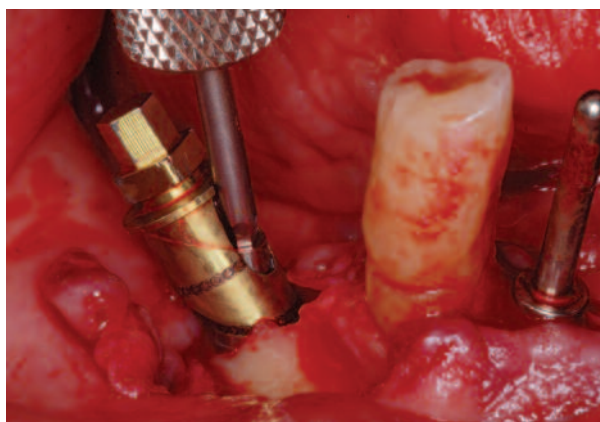
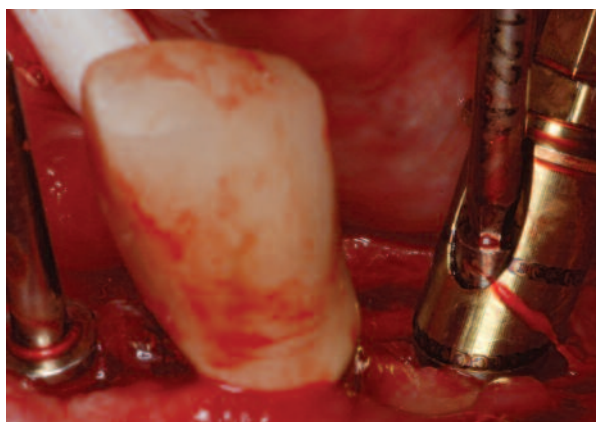


Figure 9: Clinical images of the panoramic radiograph in Figure 8 showing the orientation of the long axis of the placement head in relation to the screw axis as indicated by a hex tool.



The authors feel that the use of Co-Axis implants as the distal fixtures permits a widening of the prosthetic spread of the fixtures with placement of the implant platforms superior to the mental foramen (Figure 7 to Figure 9). Orientation of the screw access hole can be positioned on the center of the occlusal table. The 12° orientation of the Co-Axis implant will permit parallelism of the implants in the arch and allow a common path of draw for the prosthesis. Thus a screw-retained prosthesis may be used if desired, especially if an immediately placed prosthesis is to be used.

The Premaxilla

Placement of implants in the premaxilla offers its own unique set of challenges. Unlike the posterior arches or the lower anterior, the bone of the premaxilla has an inclination that tips the implant facially when placed within the confines of the available bone. An examination of natural maxillary anterior teeth reveals that the teeth have a change in angulation at the cervical so that the root follows the premaxilla angulation but the coronal orients

more vertically. When a standard implant is placed and the fixture follows the axis of the natural tooth, the prosthetic component is positioned too far facially, especially when the angle of the bone is steeper than normal. The screw access hole exits on the facial, eliminating the possible use of a screw-retained crown and increasing soft tissue complications. This necessitates use of custom abutments and commits the practitioner to use a cemented crown.

The Co-Axis implant's 12° off-axis prosthetic orientation permits the implant fixture to be placed within the confines of the available bone following the position of the natural root (Figure 10 and Figure 11). However, the prosthetic axis positions the screw access lingual to the incisal edge of the crown, allowing the use of a screw-retained crown if desired. Otherwise, if the preference is to retain the crown with cement, a stock abutment can be used with minimal or no preparation required to position the facial aspect within the proper confines to allow for placement of an esthetic crown (Figure 12 and Figure 13).



Figure 10: Illustration on a model showing a Co-Axis implant placed according to the bone available in the anterior maxilla. The placement head illustrates the long axis of the implant in relation to the long pin in the screw access hole.

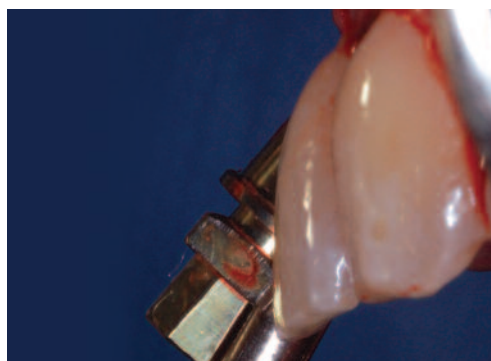


Figure 11: Clinical example of a Co-Axis implant placed in the anterior maxilla showing the bulk of the fixture mount facial to the facial surface of the adjacent tooth (implant long axis) and the prosthetic emergence shown by the long pin emerging at the incisal edge.



Figure 12: Location of the screw access of a Co-Axis implant placed on the model (Figure 10) illustrating the lingual position in relation to the long axis of the implant.

Conclusion

The use of tilted implants is being advocated by an increasing number of clinicians. Numerous possible benefits of the tilted placement of implants are found in the literature, including: significant reduction of bone grafting procedures resulting in shorter total treatment time, less patient morbidity, decreased cost, and possible immediate or early restoration which otherwise might be precluded when used in conjunction with most bone-grafting procedures; an increase in anterior-posterior spread, resulting in a more stable prosthesis; the elimination or shortening of cantilevers; the avoidance of various anatomical structures; and the facilitation of screw retention and common path of draw of implant-supported prostheses.

Placement of tilted implants into the patient's available bone is usually easier for the surgeon than additional grafting procedures, with less morbidity. One possible disadvantage of the tilted placement of conventional dental implants is that they usually become more difficult to restore. Anatomical considerations may complicate the prosthetic phase of implant treatment. When using cemented restorations, costly custom abutments with extreme angles are often required. These angles often take up valuable space, potentially creating esthetic and/or soft tissue complications. In screw-retained cases, costly angled intermediate abutments create the same potential problems and also have a second, smaller-diameter screw.

A recently developed solution to the difficulty in restoring tilted implants is the Co-Axis implant, with its 12° prosthetic axis correction built into the implant itself. This implant, therefore, helps to simplify the restoration of tilted implants, as it can overcome these issues permitting shorter treatment times and lower treatment costs. Therefore, the surgical dentist has the ability to place the implant in an

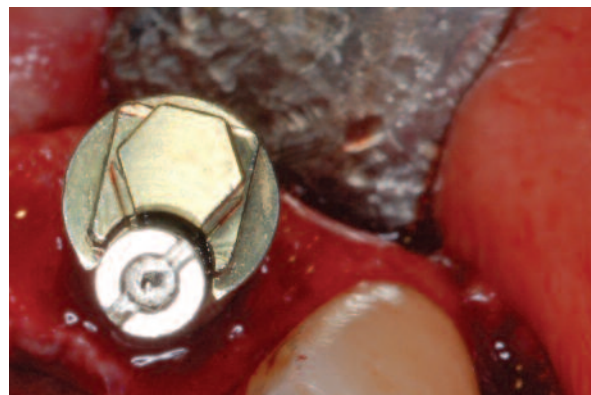


Figure 13: Clinical example of the occlusal view of the Co-Axis implant shown in Figure 11 placed at a maxillary central incisor position showing screw access in relation to the bulk of the fixture mount for a straight fixture.

ideal position and rotate it so that the restorative platform is in a position for easier restoration.

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