The Maxillary M-4: A Technical and Biomechanical Note for All-on-4 Management of Severe Maxillary Atrophy—Report of 3 Cases

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We present a technical note and 3 case reports of all-on-4 treatment of highly resorbed maxillas. The use of 4 angled implants, placed at as much as 30° off axis, that engage the lateral nasal wall bone provide high torque fixation for immediate temporization. The technique is proposed as an alternative to sinus grafting and for use with multiple implants or zygomatic implants.

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Twenty years ago, a biomechanically based site classification suggested that dental implants must have a length of 10 mm in bone and must be placed in the axial plane to obtain and maintain sufficient osseointegration.1 The treatment-planning idea during that time period was to place implants “in line,” that is, perpendicular to occlusal forces, and implied that angulated implants would lose bone and eventually “de-osseointegrate” if not placed straight up and down. Implied also by this classification was that at least 10 mm of bone was required for there to be long-term confidence in an implant restoration.2-4

In addition to these intuitive concepts, the number and distribution of implants were studied for full-arch restorations when placement was limited to the anterior zone, that is, anterior to the sinus cavities. Biomechanical analysis found that the distribution of implants was more important than the number of implants placed.5-7 For a fixed detachable bridge, the concept of an “anterior-posterior (AP) spread” was born with more favorable outcome suggested by a greater AP spread.8 Finally, with the advent of bone graft augmentation, implants began to be used in the posterior maxilla, so cantilever restorations could be avoided.9-12 However, because bone graft sites were thought to have less biomechanical strength than native bone, both increased length and number of implants were suggested for use in the posterior zone.13,14

The net treatment-planning effect of all of these ideas was for the surgical-prosthetic team to prescribe the greatest number with the greatest length and best AP spread of axially aligned implants as possible for full-arch implant restorations.15 This usually meant 6 to 8 implants for the edentulous maxilla and sometimes more. If the length of implants, number of implants, or AP spread was deemed insufficient, the final prosthesis was considered compromised by inadequate biomechanical support and treated accordingly, usually with a removable prosthesis or, if fixed, truncated cantilevers.16-19

In the last 2 decades, because of improved materials science as well as improved surgical-prosthetic techniques, these “intuitive concepts” are slowly going by the wayside, although some remain as treatment-planning vestiges of over-engineering.

About 10 years ago, further biomechanical analysis and technical advancement led to the introduction of the “all-on-4” full-arch restoration strategy, which evolved from the 6 implant–supported fixed detachable bridge.20-22 Biomechanical analysis determined that a fifth or sixth implant was unnecessary in terms of mechanical support.23 In fact, as few as 2 well-angled implants of sufficient length were calculated to be able to hold an entire arch restoration strictly based on mathematic analysis.17

All-on-4 posterior implants are placed in the maxilla angled anteriorly at 30°, just missing the anterior wall of the sinus cavity. This provides increased length and greater AP spread and often eliminates the need for bone grafting of the sinus floor.24,25
All-on-4 anterior implants are generally placed straight up and down with straight abutments or are angled slightly anteriorly when required but still placed axially. In this study we used the all-on-4 technique for anteriorly placed implants, which were also placed at up to 30° angles but were angled posteriorly in the axial plane, sometimes engaging the apex of the posterior implants (Fig 1). This convergence creates an “M” shape as seen on panoramic radiographs. Anterior implant angulations provide the same advantage as found with posteriorly angled implants, that is, increased length, increased AP spread, decreased bone grafting requirement, and, most important, increased insertion torque for primary fixation.

Designated the “M-4” technique, this approach enables an anterior placement emergence strategy even when there is only 5 to 8 mm of bone available subnasally. By angling the apex of the fixture posteriorly, just missing the nasal aperture, the spread and implant position are still maintained subnasally but 10- to 13-mm fixtures are able to be used in what otherwise would be a very limited space requiring fixtures measuring 7 mm in length or less.

After angled abutments are placed (17° or 30°), the implant distribution and abutment inclinations appear consistent with a typical all-on-4 case.

The main advantage of the M-4 technique is the increased biomechanical advantage that occurs both

![FIGURE 1. M-shaped maxillary configuration of all-on-4 technique. Implants were fixated in the dense bone found at the lateral pyriform rim.](image1)


![FIGURE 2. A and B, Posterior fixtures are placed angled forward 30°, just avoiding the anterior projections of the sinus cavity.](image2)

for the immediate-load provisional phase and for the long term.

When immediate loading is contemplated, a 10- to 13-mm fixture is much more likely to provide adequate insertion torque that will be sustainable during the provisional phase.

The use of 7-mm fixtures may lower the confidence for both short- and long-term stability.

Tilted anterior fixtures require that there be at least 5 mm of bone available. With 5 mm of vertical bone, there is enough vertical alveolar height to angle an implant into bone at the lateral pyriform rim, sometimes deriving a net implant length of up to 13 mm or more.

This previously unreported phenomenon is a vital treatment-planning option that helps to avoid bone grafting and enables immediate temporization.

Case Reports

CASE 1

An edentulous 72-year-old patient had a 25-year history of wearing dentures. Atrophy was very prominent in the maxillary anterior zone, where implants were desired to be placed because of combination syndrome. Beneath the nasal floor, only 4 to 5 mm of very thin alveolus was present for implant placement (Fig 1). The posterior fixtures were placed angled forward 30°, just avoiding the anterior projection of the sinus cavity (Fig 2).

To avoid the nasal fossa and increase the length of the anterior implants while still maintaining equalized distribution of implant emergence, the anterior implants were placed angled posteriorly toward the apex of the posteriorly placed implant (Fig 3). This enabled greater length and fixation for the implants. The implants converged, creating an M shape when viewed on panoramic radiographs, designated the M-4 all-on-4 technique (Fig 4).

CASE 2

A 48-year-old woman presented after maxillary fracture with traumatic avulsion of the left anterior alveolar process and teeth and compromised remaining bone (Fig 5).

Fracture hardware was still in place. In the anterior region, where implants were desired for an all-on-4 implant strategy, bone mass was lacking. Placing zygomatic implants or performing sinus bone grafting was considered and discussed with the patient. She declined bone grafting or extensive surgery, desiring to avoid extensive surgical intervention if possible. The M-4 all-on-4 approach was planned.

Despite the lack of alveolar height (4-5 mm), the triangle of bone at the lateral pyriform rim provided enough bone mass for M-4 placement (Fig 6). Sufficient length (10.5 and 15 mm) of implants for good
primary stability (50 N-cm) was obtained (Fig 7). The presentation on panoramic radiographs postoperatively showed an M-shaped distribution (Fig 8). Two implant apices converged at bone found between the lateral nasal wall and anterior sinus wall above the nasal floor, designated the “M point” in the M-4 nomenclature because it is the optimal apical position for fixture placement.

CASE 3

In a 66-year-old female patient, a failed upper dentition due to severe periodontal disease had nearly
resorbed the entire maxillary bone. Zygomaticus and sinus bone graft reconstruction alternatives were considered (Fig 9). In this case, after dental extraction, the anterior bone was so poor that a 30° angulation posteriorly was required to gain enough length for primary stability. The apices of the implants engaged, creating an M-4 pattern as seen on panoramic radiographs (Fig 10). Despite the osseous deficiency, using a 30° angulation for all the implants, 50 N-cm of fixation could be obtained and adequate implant length (11 and 13 mm) was achieved.

Discussion

The clinical use of an “all-on-4” strategy for implant dentistry has come into question when considering the typical resorbed edentulous maxilla—a situation most often treated with bone graft augmentation including sinus bone grafting followed by multiple implants. Use of the all-on-4 technique in the maxilla, though reported to be as successful as in the mandible, is generally viewed by the dental implant professional with skepticism. One reason for this is the presumed need to use a greater number of implants and/or the alternative of zygomatic implants.26-29

The angled fixture approach, however, offers a significant mechanical advantage as long as a favorable distribution of implants is maintained.17,30 This is not only because of the added length of implants but the added anchorage from increased surface area at both the alveolar crest point of entry and the primary fixation bone at the lateral nasal wall (Cottam J, Jensen OT, Adams M, unpublished data).

Angulation of fixtures that are well distributed and angled in opposing directions instead of simply parallel to each other provides a greater mechanical advantage than fixtures placed in parallel, given that the distribution is equivalent.

Four axially placed fixtures have less mechanical pullout strength and torsion resistance than 4 angled
fixtures when splinted together in a single-unit prosthesis. Therefore the M-4 technique may actually have a greater mechanical advantage than the standard all-on-4 approaches not including the added length provided by angulation when one considers resistance to load of the prosthesis.17

We have presented a technical note and 3 case examples suggesting that 4 angled implants (M-4) fixed at the lateral nasal rim are favorable biomechanically for immediate- and long-term loading. The technique offers sufficient biomechanical strength to permit immediate provisional restoration even in the highly resorbed maxilla. The mathematic advantage of angulation occurs independent of the advantage of increased fixture length. The M-4 is indicated for use in the highly resorbed maxilla, the Cawood Class IV/V maxilla, where there is insufficient alveolar height for vertical implant placement.

The M-4 approach is thus an added treatment strategy for the oral and maxillofacial surgeon and prosthodontist to gain implant stability without subjecting the patient to the added morbidity and cost of bone graft reconstruction and multiple implants, as well as the uncertainty of using short implants without grafting. The technique is also a viable alternative to zygomatic implants. For the prosthodontist, overall treatment remains standardized and simplified because angled abutments provide a standard prosthetic restorative scheme that can be easily addressed.

References