

Anchoring the digital mandible

Dr. Steven Vorholt illustrates fiducial strategies for predictable full-arch restorations

In fixed full-arch implant surgeries, the mandibular arch is often more straightforward and requires less surgical time than its maxillary counterpart. Barring an hourglass or deeply undercut mandible or large pathological defects, mandibular treatment planning for All-on-4 surgery is extremely predictable—map the inferior alveolar nerve paths, angle posterior implants for maximum anterior-posterior spread above the mental foramen, and add two implants in the canine-to-canine region for anterior support.

Unfortunately, the silver linings for mandibular surgery in fixed full-arch cases tend to end there. Restoring the lower arch for a same-day prosthesis is more difficult for several reasons. The mandibular anterior bone often requires more significant reduction, potentially leading to implants placed more lingual than would be considered ideal in the anterior segment. Tissue quality is generally poorer in the mandibular arch with minimal keratinized gingiva, and the excessively mobile tissue on both sides of the flap makes postoperative digital recordkeeping very frustrating—if not impossible. Bleeding is heavier and more distracting, as is the presence of the tongue and excess saliva.

When we consider the workflows that are popular today, the lower arch also poses more difficulty than the upper. While the maxilla offers a large landing area of firm, attached tissue on the palate for hard-tissue stops and denture alignment during imme-

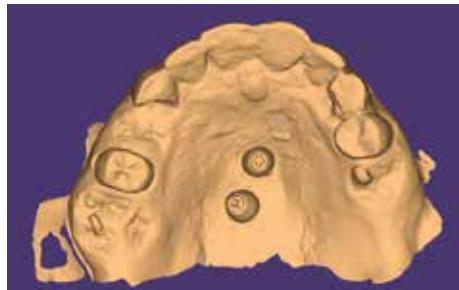


Figure 1

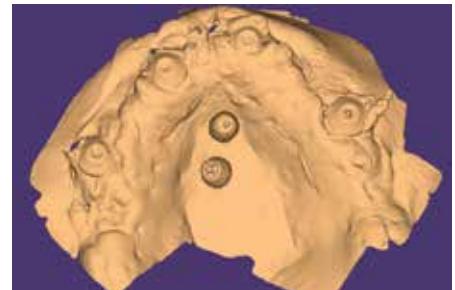


Figure 2

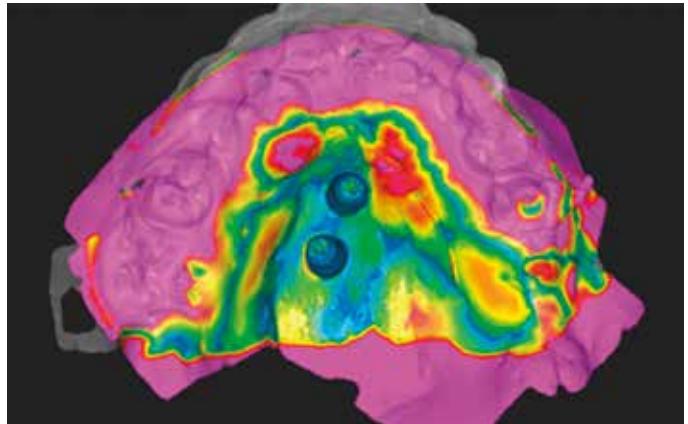


Figure 3



Steven Vorholt, DDS, graduated with a dental degree from The Ohio State University in 2013. Shortly after graduation, Dr. Vorholt started a private practice in the Columbus area. Immersing himself in as much continuing education as possible, he quickly developed a great passion for dental implant surgery.

After building a successful general practice in Ohio, Dr. Vorholt followed his passion and moved to Arizona in 2020 to accept a full-time position with Implant Pathway helping to educate over 1,000 dentists place over 15,000 implants on their paths with implant dentistry.

Dr. Vorholt is a Fellow of the American Academy of Implant Dentistry and is a Board-certified Dental Implantologist, earning his Diplomate from the American Board of Oral Implantology in 2021. He finds teaching other doctors how to successfully incorporate implant dentistry into their own practices to be his proudest professional endeavor. Dr. Vorholt currently resides and practices in Santa Barbara, California where he focuses solely on full mouth rehabilitation with dental implants using an entirely digital workflow at Santa Barbara Dental Implants.

Disclosure: Dr. Vorholt reports no conflicts of interest with the products mentioned in this article.

diate conversion, the lower denture can be difficult to align with full accuracy and stability, often leading to VDO and occlusion discrepancies. And moving to a digital workflow doesn't necessarily solve these issues. Looser, more mobile tissue is harder to scan intraorally, and excess blood and saliva make photogrammetry and IOS more technique-sensitive. By the end of a double-arch surgery, patient management fatigue starts to take its toll on everyone—the surgeon, the team, and the patient. As several systematic reviews have shown, intraoral scanning of fully edentulous arches without stable landmarks or fiducials introduces significant alignment errors and surface distortion, especially in the mandible.¹

The only fully digital technique that avoids most of these scanner-related inadequacies involves using CT bone segmentation as a fiducial reference—requiring only a low investment of a \$250,000 mobile CT unit capable of imaging sedated and supine patients. For the rest of us, there are techniques, tricks, and general principles that make the mandibular arch predictable, efficient, and less frustrating in a same-day digital restorative workflow.

Once the implants are in, and the surgery is done, the mandible usually stops being predictable and starts being a pain. Getting accurate records for a same-day prosthesis is where most of the time gets burned. The combination of mobile tissue, active bleeding, and a tongue that seems to have its own agenda makes digital data collection in the lower arch one of the most frustrating parts of full-arch surgery. Even with photogrammetry or a high-end intraoral scanner, the field contamination and tissue mobility make it tough to capture data cleanly. Numerous digital workflows have been described for capturing and aligning complete-arch implant data — including fiducial-based, scan body-based, and prosthesis-based methods — each with varying degrees of precision.²

And even when you do get a set of scans you trust, the real headache starts when it's time to merge them with the pre-surgical designs. The lack of hard landmarks in the mandible means the software is guessing, and small errors at this stage can turn into big prosthetic headaches later. Misaligned datasets lead to missed midlines, off-putting cants, changing VDOs, and prosthetics that need post-surgical adjustments or complete redesigns. The amount of time wasted on poor data is staggering, especially when you consider the downstream effects.

The maxilla spoils us. There's a wide, stable palate, attached tissue, and obvious reference points to lock in a denture or match digital landmarks (Figures 1-3 — two palatal markers are all that are necessary for a good digital stitch from the pre-surgical to post-surgical results. Note the green/blue areas on the overlay are the accurately matched portions, and they show not only the markers themselves as stable connecting points but much of the palatal tissue). The mandible gives you none of that — just slippery, movable mucosa and a lot of places for error to hide (Figures 4-6 — Compare Figures 1,2, and 3 to the mandibular

pre- and post-surgical scans, and note how the digitally overlaid data that accurately stitches is minimal and show only the fiducial markers themselves. The tissue is no help in aligning the data like it is in the maxilla) That's why efficiency in the lower arch isn't just about working faster — it's about controlling variables before they multiply. Until you have a reliable way to anchor your digital data to something stable and reproducible, the lower arch will always be the one that derails your surgical schedule and tests your patience.

Every scan, every photogrammetry capture, every "fast and easy" system ultimately depends on one thing — aligning intra-oral data with previous datasets predictably. And that's where fiducial markers quietly do the heavy lifting.

A fiducial marker, in simple terms, gives your software something to trust. It's a fixed, geometrically distinct landmark that shows up on both the pre-surgical and post-surgical intraoral scans — a digital handshake between two datasets that otherwise don't speak the same language. Taking a scan of the patient with teeth and then without teeth provides zero common ground between the two scenarios, but fiducial markers create that bridge. They're easy to visualize, stay put during scanning, and don't require extra surgical time.

The real efficiency gain isn't just the merge itself — it's what it eliminates afterward. When the datasets drop perfectly into place, you're not burning an extra 45 minutes verifying alignment or re-sending files to the designer because of an anterior open bite or one-sided occlusion. The fiducials effectively act as your insurance policy against digital drift — a way to lock the digital world back onto the reality of the patient sitting in front of you. Standardizing intraoral scanning techniques for full-arch cases is key to consistent data alignment and efficient design turnaround, as emphasized in recent classifications of complete-arch IOS workflows.³



Figure 4



Figure 5

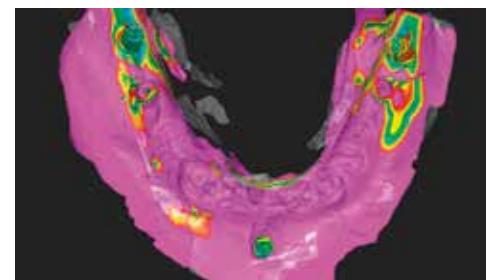


Figure 6



Figure 7

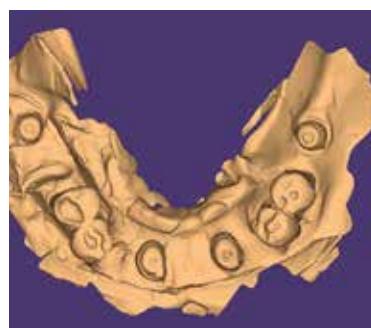


Figure 8



Figure 9

Let's talk about where, how, and what to use as fiducial markers in the mandible, and some time-saving ideas that can keep the frustration to a minimum and the case moving forward.

The big idea for mandibular fiducial theory is a tripod. Having stable markers arranged in a triangle prevents accidental digital "slippage" or tilting on the axis of two sole markers. In the maxilla, one can often get away with a single marker on the palate thanks to the palatal tissue and slope acting as a natural fiducial. In the mandible, though, placing two markers — one in each posterior quadrant — allows for anterior-posterior error because the reference field is so small compared to the entire arch. Those small misalignments show up as anterior open bites more often than not.

Look for markers in each posterior sextant and at least one in the anterior mandible. The fiducial marker can be anything that is stable, scannable, has unique geometry, and will be present in both the pre- and post-surgical scans. Common markers are available from companies like Digital Arches (ArchTracer™), 3D-printed markers fixed with bone screws, or selective patient teeth — often canines and/or second molars — that don't interfere with the surgical plan and can serve as the digital bridge between pre- and post-surgical scans.

If the remaining teeth are not healthy enough for temporary retention (periodontally mobile, broken to the gumline, or absent) or are in the direct path of the implant plan, a surgical

marker can be placed in the anterior mandible instead. One trick for the anterior marker is to upright it as much as possible so it aligns with the posterior markers in the path of draw. Because we often take analog impressions of the lower arch post-surgery, we want to ensure all three markers can be captured in the same tray. Aiming for the mental protuberance at the depth of the vestibule is the most common location for the anterior marker.

A small incision is made at the depth of the vestibule to bone, and the marker is placed. This helps minimize bleeding and heme that could interfere with pre-surgical scans. After the initial scans, the vertical incision can be extended and connected with the crestal or sulcular incision for flap reflection (Figures 13-17 — Initial placement is through a small incision at the depth of the vestibule, aiming for the mental protuberance [Figure 14]. After pre-surgical scan is obtained, the vertical incision is completed to the crest [Figure 15]. One can see the positioning is to most closely match the path of draw in the posterior [Figure 16] for ease of capturing the marker in an impression. Be sure to place the marker below the planned plane of alveoplasty [Figure 17].

Leaving teeth as fiducials is a great way to expedite surgery when possible. (Figures 7-9 — In this example, the premolars were temporarily retained to serve as a mid-way scan to align the pre-surgical with the mid-surgical result. Note the significant area of digital alignment utilizing the four natural teeth.) (Figures 10-12 — Following up to the previous example, the

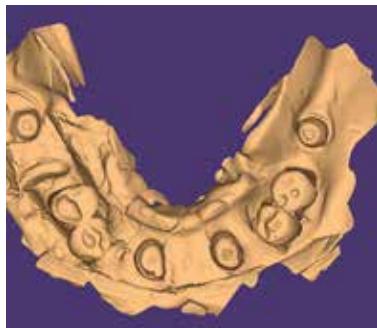


Figure 10

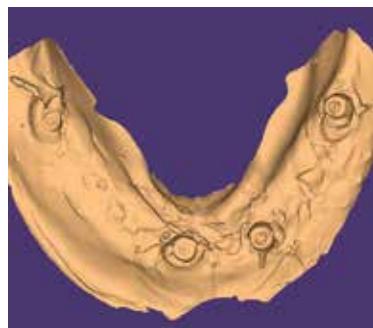


Figure 11

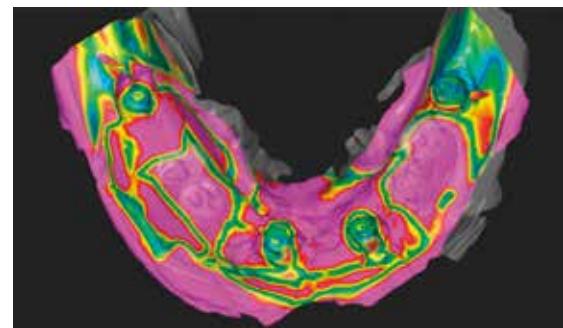


Figure 12

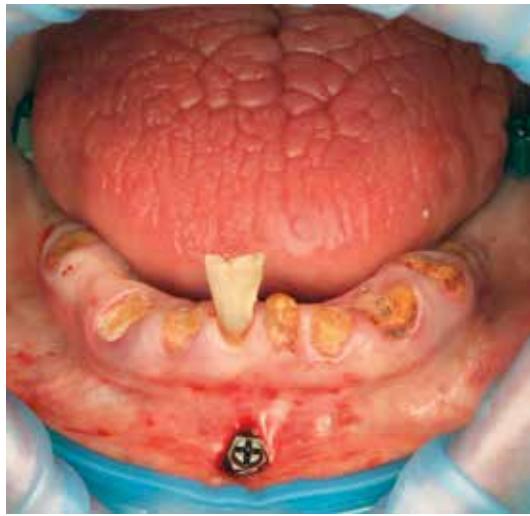


Figure 13

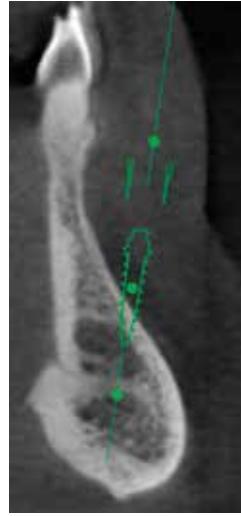


Figure 14



Figure 15

premolars were extracted and the case sutured closed; now we see the digital overlap is with the MUA caps that were present in the mid-surgical scan and the final surgical scan. Utilizing these mid-surgical scans does add some time to the surgery, but allows for accurate alignment across the surgery.) With teeth as markers (for example, second molars and one canine), the surgeon can complete alveoplasty, place the implants and abutments, take the final photogrammetry scans, and capture a post-surgical tissue scan with the temporarily retained teeth. The lab can then use those teeth to align the pre-op and post-op data, digitally extract the remaining teeth to the alveoplasty plane, and begin design immediately.

Speaking of design time, the largest opportunity for time savings in digital full-arch surgery is getting the design team started as soon as possible with the data they need. I use a bone-level impression with Silginat® (Kettenbach Dental) or another PVS alternative. This captures the final implant positions, aligns with the photogrammetry, and lets the surgeon inform the design team how much space to leave between the prosthetic intaglio and the bone based on gingival thickness and personal preference. This allows the design team to start their digital conversion before the temporarily retained teeth are removed and before suturing or soft-tissue work begins. Suturing alone can take 30 to 40 minutes, and allowing the design team to work during that time means the team isn't waiting, doesn't feel rushed during closure, and the design is often ready right as suturing wraps up.

One concern with leaving teeth temporarily retained during surgical scans is their final removal. Extracting a lone canine is never easy, but it's especially stressful when it's flanked by implants, and bone preservation is critical. Second molars rarely cause the same level of concern — they can be sectioned and removed safely, and implants are usually not close enough to risk a defect. For that reason, when I choose a canine to retain as a fiducial marker, I often perform vital root banking.⁴

Vital root banking has been studied for decades,⁵ but it's still outside many practitioners' comfort zones. It feels wrong to section a vital tooth, expose the pulp, and bury it under the flap — but it works. As with any technique, there are risks — exposure, infection, mobility — that the surgeon must be comfortable addressing. But the benefits outweigh them. The bone in the area of a root-banked tooth is preserved through the periodontal ligament, with no risk of buccal plate loss during removal. The tooth is sectioned to the alveoplasty level with a sharp carbide to minimize heat, then a fine diamond football or round bur is used to countersink the vital root 1–2 mm below the bone. Full primary closure is essential, but additional membranes or grafting are rarely necessary.

Conclusion

The mandibular arch will probably never be as forgiving as the maxilla — but with a disciplined approach to fiducial place-

“There are techniques, tricks, and general principles that make the mandibular arch predictable, efficient, and less frustrating in a same-day digital restorative workflow.”



Figure 16

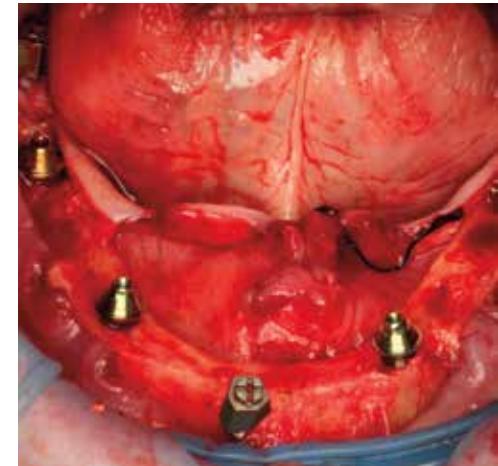


Figure 17

ment and smart coordination with the design team, it doesn't have to be the stress test of every full-arch day. Fiducials create a repeatable digital language between pre- and post-surgical scans, letting surgeons work faster, labs design smarter, and patients spend less time under anesthesia. Whether the markers come from teeth, screws, or printed jigs, what matters most is the planning and communication that tie the whole system together. When those fundamentals are solid, the digital mandible stops being a liability and becomes one of the most predictable, efficient workflows in implant dentistry. **P**

REFERENCES

1. Deferm JT, Baan F, Nijsink J, Verhamme L, Maal T, Meijer G. Intraoral scanning of the edentulous jaw without additional markers: An *in vivo* validation study on scanning precision and registration of an intraoral scan with a cone-beam computed tomography scan. *Imaging Sci Dent*. 2023 Mar;53(1):21-26. doi: 10.5624/isd.20220131. Epub 2023 Feb 1.
2. Revilla-León M, Kois JC. Implant Scanning Workflows for Fabricating Implant-Supported Prostheses Recorded by Using Intraoral Scanners With or Without Photogrammetry Technologies. *J Esthet Restor Dent*. 2025 Jun;37(6):1384-1391. doi: 10.1111/jerd.13431. Epub 2025 Feb 5.
3. Revilla-León M, Gómez-Polo M, Rutkunas V, Ntovas P, Kois JC. Classification of Complete-Arch Implant Scanning Techniques Recorded by Using Intraoral Scanners. *J Esthet Restor Dent*. 2025 Jan;37(1):236-243. doi: 10.1111/jerd.13322. Epub 2024 Sep 27.
4. Du Toit J, Salama M, Gluckman H, Nagy K. Root submergence technique as a partial extraction therapy to preserve the alveolar ridge tissues: A systematic review and appraisal of the literature. *J Prosthet Dent*. 2023 Aug;130(2):187-201. doi: 10.1016/j.jprostdent.2021.08.009. Epub 2021 Nov 6.
5. Dugan DJ, Getz JB, Epker BN. Root banking to preserve alveolar bone: a review and clinical recommendation. *J Am Dent Assoc*. 1981 Nov;103(5):737-743. doi: 10.14219/jada.archive.1981.0367.