Photogrammetry and the Cost of Efficiency

Rethinking Accuracy and Responsibility in Full-Arch Dentistry

By Dr. Leila Zadeh

Success with full-arch implant prostheses depends on understanding how chairside clinical choices shape outcomes at the lab bench. As a dual-trained dentist and technician, I care deeply about this intersection of clinical dentistry and laboratory work, and I have learned that "good dentistry" in complex restorative cases is rarely achieved by any single tool alone. Instead, it is the culmination of how accurately our records capture reality, and how faithfully they translate through a workflow, with as little distortion as possible, until the final prosthesis is seated and maintained over time.

Photogrammetry (PG), is one of the more powerful examples of this principle in modern implant dentistry, and some common examples on the market include the iCam4D (iMetric), MicronMapper (S.I.N. 360), PIC System (PIC Dental), and Blue Sky Bio Grammee (powered by Tupel 3D). For fixed, multi-unit implant prostheses, PG can help speed up the final impression appointment by reducing steps, and it can be a reliable tool for recording implant positions.[4,5] However, it is an expensive technology not without challenges and added responsibilities, especially when efficiency becomes the primary motivator rather than quality.

The Challenge of Full-Arch Analog Workflows

If you have ever restored a full-arch fixed implant prosthesis using a traditional analog workflow, you know the feeling: an entire morning or afternoon block can be consumed, the patient becomes restless, and the operator takes on the roles of clinician, laboratory technician, therapist, and project manager simultaneously. Even when everything goes "well," the process can be technique sensitive and time intensive.

The issue is not that analog methods are inherently inferior. The issue is how many steps they often require. And the more steps involved in any workflow, the higher the risk of cumulative error. Each individual step introduces variability, including material distortion, component seating discrepancies, resin shrinkage, cast inaccuracies, mounting errors, and operator technique. Even small deviations can become clinically meaningful when passive fit is compromised.

While digital workflows do not eliminate error, they can reduce the number of opportunities for error to be introduced. And PG is a prime example.

What Photogrammetry Captures

PG is a method of approximating three-dimensional relationships using two-dimensional images. In implant dentistry, PG systems capture the 3D spatial relationship of implants relative to one another. That relationship can then be exported and used in computer-aided design (CAD) software to design a framework or fixed multi-unit implant prosthesis.[1]

Why is this important? Because passive fit is a requirement for long-term mechanical stability and biologic health. Inaccurate implant position transfer can introduce stress into the prosthesis-implant complex and increases the risk of complications such as screw loosening, fracture, and peri-implant bone loss over time.[2,3]

One of the reasons PG has gained traction is its ability to essentially bring the precision of a controlled extraoral scanner (ie. desktop scanner) to the mouth. This is especially important for long edentulous spans, where each additional implant increases the complexity of accurately transferring these spatial relationships, and therefore increases the risk of prosthesis misfit.

Accuracy of Different Full-Arch Impression Workflows

It is tempting to assume that an intraoral scan alone can serve as the final impression for a full-arch implant restoration. In reality, intraoral scanning of edentulous arches remains challenging because these scanners perform best when capturing rigid, non-movable structures with unique surface detail, such as teeth. Intraoral scanners rely on linking together multiple sequential images, and this

stitching process is more likely to accumulate error across long spans. Additional factors such as scan path, tissue mobility, saliva, blood, the presence of poor-quality oral landmarks, and patient movement can further compromise accuracy.

PG bypasses the issue of stitching error, which is why it is positioned as a high-accuracy method for full-arch implant position transfer. However, while PG can improve the accuracy of capturing long-span implant spatial relationships when compared with intraoral scanning alone, it is not a perfect solution. PG accuracy is influenced by the specific system used, the condition, positioning, and seating of implant components and markers, and the clinical environment in which the data is captured.[1,3,4,6]

When comparing PG, intraoral scanning, and conventional analog workflows, it is essential to recognize that accuracy is influenced by how the impression process is performed. This is why meaningful comparisons require careful consideration of system design, component selection, clinical protocol, and operator experience. Continued research is needed to further investigate how these variables influence accuracy in full-arch implant impressions.

Treatment Maxillary anterior **IMPLANT PROVISIONAL BRIDGE** and mandibular **OVERDENTURE TRY-IN** made with **Exocad** and **iMetric** softwares to test drive esthetics and phonetics prior to delivery of final prostheses

Where Photogrammetry Adds the Most Value

PG is useful in situations involving long edentulous spans, which carry high consequences for small inaccuracies due to strict passive fit requirements. In these cases, reducing the number of technique-sensitive impression steps to capture implant positions can improve efficiency and also simplify appointments that historically required substantial chair time.

Although most commonly associated with full-arch workflows, it is important to note that PG can be used selectively for implant bridges. In the case example shown here (Figure 1), rather than spending time splinting analog implant impression copings with floss and low-shrinkage acrylic or resin, PG was used in lieu of such a jig to efficiently capture the implant positions for a #7-11 milled PMMA implant provisional bridge (with implants at sites #7, 9, and 11, and pontics at sites #8 and 10). I was able to do this because I had sufficient restorative space for Nobel-compatible multi-unit abutments (MUAs), which are needed to use the iMetric PG unit. So keeping in mind the expense of MUAs, the necessary restorative space, and the unique demands of your particular PG system are critical with respect to case selection.

The advantage of an abutment-level approach is straightforward. Restoring and impressing can become more efficient and more streamlined. However, the tradeoffs must be acknowledged. Multi-unit abutments consume restorative space, which can be a significant design constraint in shorter-span cases, and their cost may be more difficult to justify outside of full-arch reconstructions.

The Reality of Model-Less Workflows

PG workflows are often model-less, which is frequently celebrated because it removes steps from the process. From a bench-to-chairside perspective, however, model-less workflows introduce a new tradeoff: the loss of a traditional verification checkpoint prior to final delivery.

A verified master cast allows:

- Extraoral evaluation of framework fit and passivity, and
- Cementation procedures (ie. titanium base cementation on a model)

Model-less workflows can still produce excellent outcomes, but they require the team to recognize what has been removed from the process and to replace it with appropriate clinical validation. That means being uncompromising about:

- Confirming complete seating of components
- Checking passivity clinically and radiographically
- Ensuring occlusal design respects biomechanics and material constraints

One consequence of the increased use of model-less workflows is the growing popularity of printing or milling prostheses directly to MUAs using special screws that bypass the need for titanium bases. More and more of these "direct-to-MUA screws" are hitting the market to meet growing demand, including the DESS Full Arch Multiunit, Powerball, SIN Screws, Vortex, and Rosen screws, most of which now come with angle-correcting options. However, until more long-term evidence in the literature is released regarding their performance, careful consideration of material interfaces remains essential. For this reason, my preference is to reserve direct-to-MUA screws for provisional prostheses (as was done with the use of Vortex screws in the illustrated case in Figure 1), while preserving metal-on-metal interfaces for definitive prostheses (ie. tibases for monolithic zirconia or a titanium bar with a monolithic zirconia sleeve cemented on top).

When Efficiency Demands Responsibility

Two modern realities are shaping restorative implant dentistry. The population is growing and aging, increasing the overall need for restorative care, while the dental laboratory workforce has not expanded at a comparable rate. This imbalance has created a bottleneck in laboratory capacity, contributing to rising laboratory costs. In response, many dentists are taking on a greater share of laboratory-related tasks to manage costs, increasing the pressure to improve efficiency across clinical workflows.

Digital tools such as PG can reduce chairtime, simplify appointments, and make more complex care more scalable. However, when advanced workflows become easier to execute, there is a risk that case selection and planning are influenced more by convenience rather than by patient-specific biologic considerations and long-term maintainability.

The responsibility remains with the dentist to select workflows because they best serve the patient's biology, functional requirements, and long-term restorative needs, not simply because they make the clinical day more efficient. We must educate patients about alternatives, risks, and benefits, tailor restorative planning to respect and preserve patients' anatomy whenever possible, communicate clearly with the laboratory about design intent, and take ownership of accurate implant position capture and the resultant prosthesis fit.

If there is one bench-to-chairside lesson worth carrying forward, it is that accuracy in full-arch implant dentistry is not an automatic consequence of digital workflows. It is a clinical responsibility that must be intentionally preserved. Photogrammetry can raise the ceiling of what is possible, but only when it is selected thoughtfully, validated rigorously, and used in service of long-term biologic and restorative success rather than short-term efficiency. ■

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Leila Zadeh, DMD, FAGD, *is an advanced restorative dentist, the Director of Digital Clinical Content at Spear Education, and an adjunct assistant professor in the Advanced Education in General Dentistry (AEGD) residency program at NYU Langone Health. She also practices part time as an associate dentist at Revive Dental Implant Center. Dr. Zadeh reports no conflicts of interest related to this article.*