

Computer-aided Design vs Conventional Design and Bite Transferring Method for Full Mouth Rehabilitation

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Abstract

Currently, computer-aided design/computer-aided manufacturing (CAD/CAM) is widely used in dentistry. The application of CAD/CAM has numerous advantages over conventional techniques, such as the processing time and error of final restoration were decreased. In addition, the information of provisional restorations transfers to fabricate final restorations was easily and highly accurate. Full mouth rehabilitation is a comprehensive and complicated procedure. The CAD/CAM is considered to be an alternative technique to the cross-mount technique to produce the precise final restoration through the accurate transfer information of provisional restoration. However, the application of CAD/CAM requires an understanding of the basic concept, digital technologies, and good communication between dentist and technician to create the precise and esthetic outcome of the final restoration.

Keywords: bite transferring, CAD/CAM, cross-mount, full mouth rehabilitation

Introduction

Digital dentistry may be defined as dental technology or device that incorporates digital or computer-controlled components in contrast to that of mechanical alone.⁽¹⁾ The digital dentistry computer-aided design/computer-aided manufacturing (CAD/CAM) has advantages in comparison to the conventional technique.^(2,3) The CAD/CAM for dental manufacturing and the dental laboratory profession is already in the early majority and will soon approach.⁽¹⁾ The dental laboratory profession has discovered what the clinicians have been recognized CAD/CAM works. It is faster, more economical, predictable, consistent, and relatively accurate. The advantages may be diminished by the increased cost or technique sensitivity.⁽²⁾

On the other hand, chairside intraoral imaging, and fabrication of indirect restorations by the clinician have been available for more than 25 years.^(4,5) However, even with new competition driving faster innovation, the price remains high, and adoption has not yet reached the early majority.

Advantages of computer-aided design^(1-3,5)

1. Computer-aided design decreased the time to fabricate final restoration when compared to the conventional method.
2. Information transfers from provisional restoration to final restoration were highly accurate.
3. Chair times were reduced, especially in the insertion of the final restoration visit.
4. Communication about design, revision of design between dentist and the dental technician was easy.
5. The errors during final restoration processing were easily corrected due to the data of computer-aided design was ready for fabrication.

Disadvantages of computer-aided designed^(1,2,5)

1. The major limitation of most areas of digital dentistry is cost.
2. One of the common pitfalls in adopting new dental technology is the lack of desire on the part of the clinician and team to be adequately trained. Some

clinicians will purchase a new technology but never read the owner's manual or seek advanced training on how to operate the technology efficiently, often leading to high failure and abandonment.

3. Misunderstanding the new technology tends to foster slower adoption rates. This scenario can be easily avoided by greater attendance of basic and advanced hands-on courses in these areas of technology.

Full mouth rehabilitation is complicated work in dentistry. Fabrication of provisional restoration is an important step to clarify the achievement of work. Assessment of centric relation, eccentric relation, vertical dimension, and esthetic after fixed provisional restoration should be done before final impression.^(6,7) Because this important information from provisional restoration was communicated to a dental technician for the final restoration fabrication.⁽⁷⁾ The information transfer was very difficult. The previous study suggestion was as followed:

Cross-mount technique

1. Once full mouth preparation was done, verifications of provisional restoration can be as followed:

1.1 Centric relation: Patient moved mandible to centric relation position, repeatable, and function in this position without any symptoms.^(8,9)

1.2 Eccentric relation: This position corresponded with the diagnostic wax-up position from the treatment plan. There was no interference in all positions, no contact on the balancing side, no contact on posterior teeth in a protrusive position.⁽⁹⁾

1.3 Vertical dimension: Assessment of occlusal vertical dimension and rest vertical dimension for calculated interocclusal rest space.⁽¹⁰⁾ Then verify of this positions were as followed:

1.3.1 Be able to function in this position

1.3.2 No pain on masticatory muscle and temporomandibular joint

1.3.3 No teeth contact in rest vertical dimension and during speaking

1.4 Esthetic: Assessment of esthetic was very difficult because of its individual. However, evaluation of esthetic was as followed^(11,12):

1.4.1 Level of the incisal edge should be below upper lip 0.5-1.0 mm at rest position

1.4.2 Level of the incisal edge should be above lower lip 1.0-2.0 mm at smile position

1.4.3 Plane of anterior teeth should be parallel to interpupillary line

1.4.4 Midline should be parallel to midface (mid-nose)

1.5 Margin: Margin between provisional restoration and abutment should be fit. Otherwise, improper fitting of gingival margin brings about inflammation.⁽¹³⁾ The bleeding from the inflammation be the cause an inadequate quality of the final impression and cementation of final restoration.⁽¹⁴⁾

Subsequence to verifying provisional restoration, the next step was bite registration.

2. Bite registration^(15,16)

Bite registration (Ramitec, 3M, Canada) was created 2 times: first for mount upper and lower master cast, second for mount upper provisional cast, and lower master cast.

2.1 First bite registration: Bite registration was divided into 3 sections. First, inserted provisional restoration at anterior and left posterior region. Then, injected bite registration material on right posterior region (Figure 1). Second, inserted provisional restoration at left posterior region and insertion of bite registration on right posterior region. Bite registration material was injected on anterior region (Figure 2). Third, insertion of bite registration on right posterior region and anterior region. Bite registration material was injected on left posterior region (Figure 3). This bite registration was used for mount master cast on the articulator.

2.2 Second bite registration: Provisional restoration was fixed on the maxillary arch then bite registration was a similar procedure as 2.1 (Figure 4-6). This bite registration was used for mounting provisional cast and lower master cast on the articulator. After that provisional restoration was fixed on the mandibular arch. Upper and lower provisional restoration were impressed using alginate (Kromopan, Lascod, Italy). These impressions were poured with stone type III for the provisional cast. The final impression for the master cast was taken using polyether (Impregum, 3M, Canada). These impressions were poured with stone type IV for the master cast. Arbitrary face-bow was used to record the relationship between maxilla and base of skull. Then, transfer to the articulator.

3. Mounting on the articulator^(7,17,18)

3.1 Upper provisional cast was mounted on the articulator using face-bow record.



Figure 1: Representative. (A) The insertion of provisional restoration on anterior and left posterior region, (B) Bite registration on right posterior region.

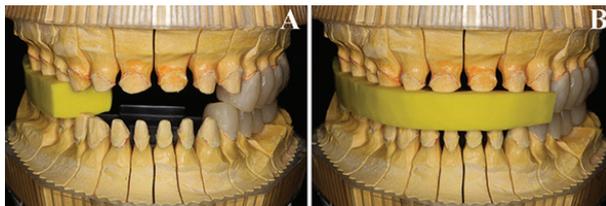


Figure 2: Representative. (A) The insertion of bite registration on right posterior region and provisional restoration on left posterior region, (B) Bite registration on anterior region.

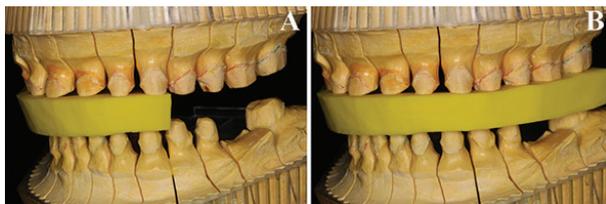


Figure 3: Representative. (A) The insertion of bite registration on right posterior region and anterior region, (B) Bite registration on left posterior region.

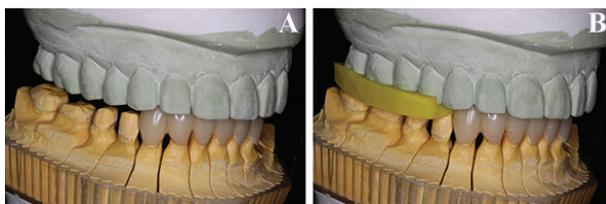


Figure 4: Representative. (A) The insertion of provisional restoration on the maxillary arch, anterior, and left posterior region of the mandibular arch, (B) Bite registration on right posterior region.

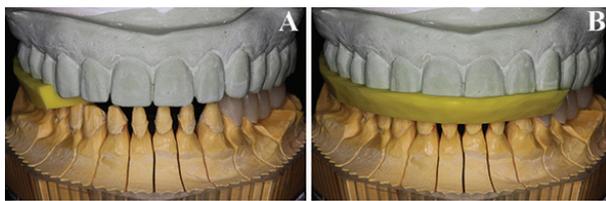


Figure 5: Representative. (A) The insertion of bite registration on right posterior region and provisional restoration on left posterior region, (B) Bite registration on anterior region.

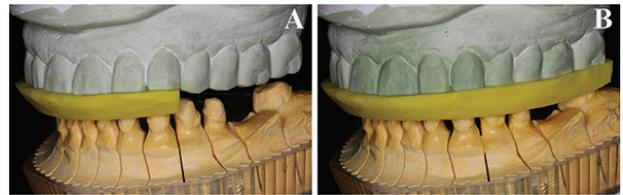


Figure 6: Representative. (A) The insertion of bite registration on right posterior and anterior region, (B) Bite registration on left posterior region.

3.2 Lower master cast was mounted on the articulator using bite registration from 2.2 (Figure 7).

3.3 Upper master cast was mounted on articulator using bite registration from 2.1 (Figure 8).

4. Waxing

4.1 The waxing of final restoration was created on lower master cast occluded with the upper provisional cast (Figure 9).

4.2 The waxing of final restoration was created on upper master cast occluded with the lower master cast (Figure 10).

The eccentric relation position was verified. The relationship between the upper and lower provisional cast, upper provisional cast and lower master cast, and upper and lower master cast at the eccentric relation position were similar. The working side position was mutually protected occlusion on both right and left sides (Figure 11-12). Protrusive position contacted on 11/41, 42 and 21/31, 32 respectively (Figure 13).

5. Fabricated final restoration

The information transferred from provisional restoration to final restoration using the cross-mount technique was quite completed. But information about contour, axis, and alignment may be inadequate. In addition, the conventional waxing technique required 3-4 days while computer-aided design was accomplished within 1 day (Figure 14-15).

Computer-aided design

In the case of full mouth rehabilitation, a conventional final impression technique was required because 3D printing of master cast from digital impression using intraoral scan was unreliable.

1. The fabricated procedure of provisional restoration was the same as the cross-mount technique.

2. The bite registration procedure was created only 1 time same as 2.1.



Figure 7: Representative lower master cast was mounted on the articulator. (A) The right lateral view, (B) The frontal view, (C) The left lateral view.



Figure 8: Representative upper master cast was mounted on the articulator. (A) The right lateral view, (B) The frontal view, (C) The left lateral view.



Figure 9: Representative waxing final restoration on the lower master cast. (A) The right lateral view, (B) The frontal view, (C) The left lateral view.



Figure 10: Representative waxing final restoration on upper master cast in centric relation position. (A) The right lateral view, (B) The frontal view, (C) The left lateral view.



Figure 11: Representative the right working side position was mutually protected occlusion. (A) The upper and lower provisional cast, (B) The upper provisional cast and lower master cast, (C) The upper and lower master cast.



Figure 12: Representative the left working side position was mutually protected occlusion. (A) The upper and lower provisional cast, (B) The upper provisional cast and lower master cast, (C) The upper and lower master cast.



Figure 13: Representative protrusive position contacted on 11/41, 42, and 21/31, 32. (A) The upper provisional cast and lower master cast, (B) The upper and lower master cast.



Figure 14: Representative final restoration in centric relation position. (A) The right lateral view, (B) The frontal view, (C) The left lateral view.



Figure 15: Representative final restoration in the eccentric relation position. (A) The right working side was mutually protected occlusion, (B) The protrusive position contacted on 11/41, 42 and 21/31, 32, (C) The left working side was mutually protected occlusion.

3. A water pencil was used for marking a mark on soft tissue. Three markers were created on the attached gingiva on the left canine, right canine, and first molar area under the gingival margin 8 mm. If the markers were located less than 8 mm from the gingival margin. The markers may be destroyed during the die fabrication process. In addition, the remaining natural teeth, screw hold of an abutment, and screw hold of healing abutment of the implant were adequate markers because of its stable position. The impression for the provisional cast was taken using alginate and the final impression for the master cast was taken using polyether.

The completed superimposition between the provisional cast image and the master cast image was required three markers. The superimposition procedure was unreliable when using less than 3 markers.⁽¹⁹⁾ Soft tissue alone was the strong contraindication for markers due to their movable behavior. The movement of soft tissue during impression created the difference in position of the soft tissue between the provisional cast image and the master cast image.

4. Upper and lower master casts were mounted on articulator using bite registration from 2.1

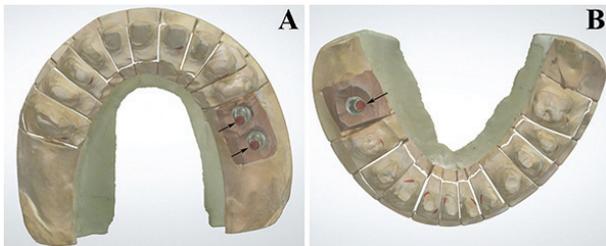


Figure 16: Representative. (A) The upper master cast image; the 2 markers on 25 and 26 screw hold of abutment, (B) The lower master cast image; the 1 marker on 46 screw hold of abutment (Black arrows represent markers).

5. The upper and lower master casts were separated scan using a lab scan (3shape, E3, Denmark) with an average trueness of $42 \mu\text{m}$ and an average precision $28 \mu\text{m}$ ⁽²⁰⁾ (Figure 16). Upper and lower master casts were simultaneously scan using a lab scan in bite registration position (Figure 17). The bite registration position scan was a very crucial position that was necessary for occlusal contact designed especially in an eccentric relation position.^(7,18)

6. Upper and lower provisional cast were separated scan using lab scan^(7,18) (Figure 18-19). Upper and lower provisional casts were simultaneously scan using lab scan in bite registration position (Figure 20).

7. Three markers on the provisional cast image and the master cast image were simultaneously and clearly.⁽¹⁹⁾ The PLY or DCM file were recommended in this technique. The master cast image had markers on 25, 26, 46 screw hold of the abutment (Figure 16), and buccal areas of 13, 33, 43 (Figure 17). The provisional cast image had markers on healing abutment on 25, 26 (Figure 18) and buccal areas of 13, 33, 43 (Figure 19-20).

8. Superimposition of the master cast image and the provisional cast image was completely created using 3 markers as above mentioned (Figure 21-23).

9. In the case of intraoral scan was used to create the provisional restoration image and abutment preparation image. The provisional image and abutment preparation image were superimposed using soft tissue⁽¹⁴⁾ (Figure 24-26). This superimposition technique was accurate than the scan cast technique because of the stable position of soft tissue. The stability of soft tissue between provisional restoration image and abutment preparation image, the 3 markers may be unnecessary.⁽¹⁹⁾

10. Information after superimposition of provisional cast image and the master cast image were completely



Figure 17: Representative the upper and lower master cast were simultaneously scan using lab scan in bite registration position. (A) The right lateral view, (B) The frontal view, (C) The left lateral view (Black arrows represent markers).

transferred. The contour, axis alignment, occlusal plane, length of teeth of final restoration were created using a computer-aided design⁽⁷⁾ (3Shape Dental Manager version 2020) (Figure 27-29). This technique provided accuracy and decreased time when compared to the conventional technique. The final restoration designed was verified using the superimposition of the provisional cast image (Figure 30-32) as followed:

10.1 The green color of the provisional cast image should be completely superimposed with the yellow color of the final restoration design (Figure 27-29).

10.2 The completed superimposition indicated that entirely transferred information from provisional cast image to the final restoration.

10.3 The yellow color after superimposition indicated that over the contour of final restoration designed. While the green color after superimposition indicated that the under contour of final restoration was designed (Figure 30-32).

11. Final restoration was fabricated using computer-aided design.

11.1 Fabrication process was depended on the type of final restoration. Three-dimensional printing was used for IPS e.max Press to created wax of final restoration. Then, lost-wax and heat-press techniques were processed.

11.2 Milling of final restoration was used for zirconia material (Figure 33).

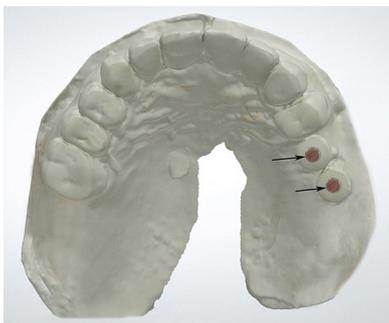


Figure 18: Representative the 2 markers of upper provisional cast were on 25 and 26 screw hold of the healing abutment (Black arrows represent markers).

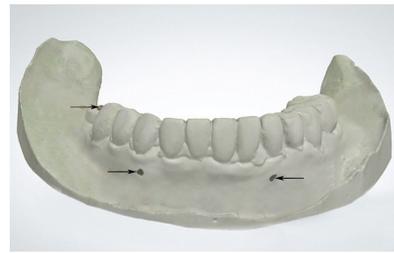


Figure 19: Representative the 3 markers of lower provisional cast were on 46 screw hold of healing abutment and 43, 33 buccal areas (Black arrows represent markers).

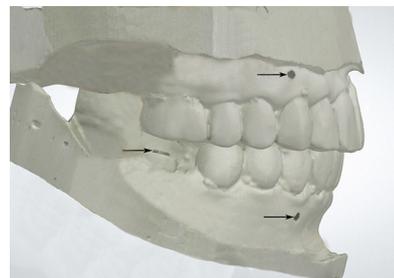


Figure 20: Representative the 3 markers of upper and lower provisional cast were on 46 screw hold of healing abutment and 43, 13 buccal areas (Black arrows represent markers).

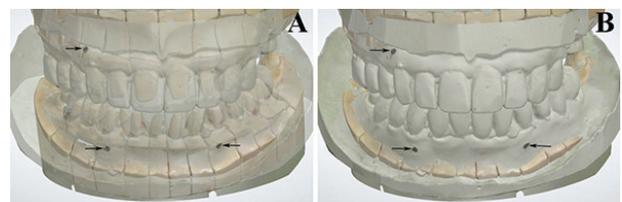


Figure 21: Representative the frontal view. (A) The superimposition of the master cast image and the provisional cast image in translucency mode, (B) The superimposition of the master cast image and the provisional cast image (Black arrows represent markers).

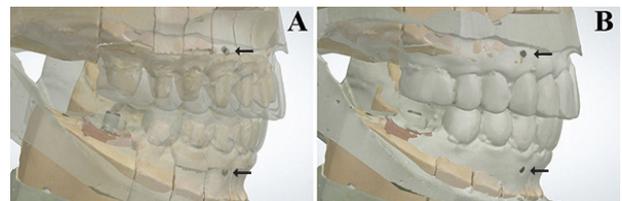


Figure 22: Representative the right lateral view. (A) The superimposition of the master cast image and the provisional cast image in translucency mode, (B) The superimposition of the master cast image and the provisional cast image (Black arrows represent markers).

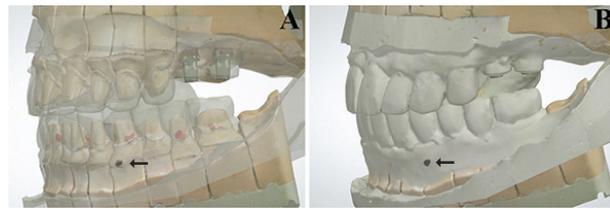


Figure 23: Representative the left lateral view. (A) The superimposition of the master cast image and the provisional cast image in translucency mode, (B) The superimposition of the master cast image and the provisional cast image (Black arrows represent markers).



Figure 24: Representative the natural-color images of the maxillary arch were presented after intra-oral scanning. (A) The abutment preparation image, (B) The provisional restoration image, (C) The superimposition of the abutment preparation image and the provisional restoration image.

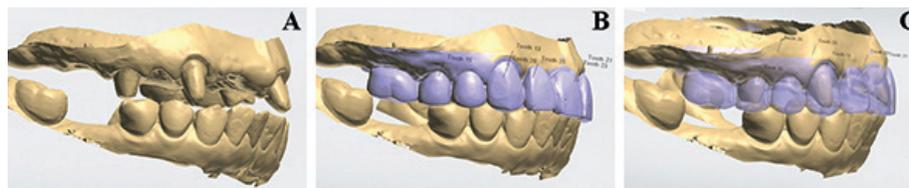


Figure 25: Representative the right lateral view. (A) The abutment preparation image, (B) The provisional restoration image, (C) The superimposition of the abutment preparation image and the provisional restoration image.



Figure 26: Representative the left lateral view. (A) The abutment preparation image, (B) The provisional restoration image, (C) The superimposition of the abutment preparation image and the provisional restoration image.



Figure 27: Representative the front view of final restoration designed.

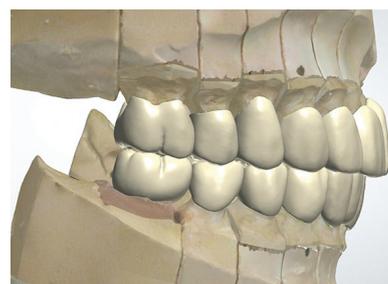


Figure 28: Representative the right lateral view of final restoration designed.



Figure 29: Representative the left lateral view of final restoration designed.

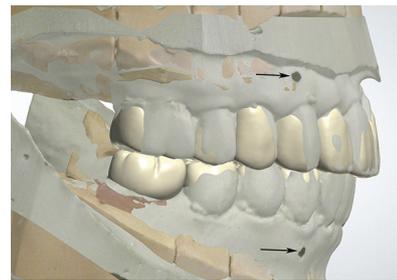


Figure 31: Representative the right lateral view of final restoration designed was verified using the superimposition of the provisional cast image.



Figure 30: Representative the frontal view of final restoration designed was verified using the superimposition of the provisional cast image (Black arrows represent markers).



Figure 32: Representative the left lateral view of final restoration designed was verified using the superimposition of the provisional cast image (Black arrows represent markers).

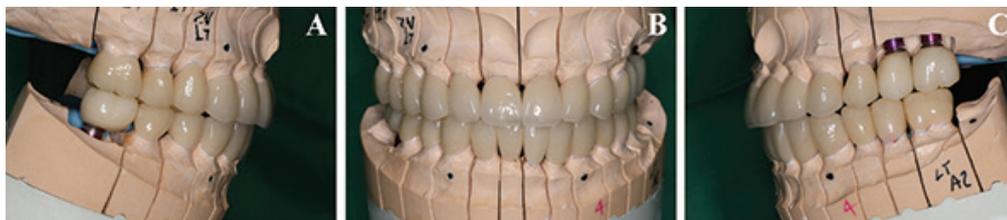


Figure 33: Representative final restoration were fabricated using computer-aided design. (A) The right lateral view, (B) The Frontal view, (C) The left lateral view.

Conclusions

Digital technology in dentistry is created and developed to improve the accuracy and reliability of prostheses. However, this technology requires the understanding, communication, and cooperation between dentists and dental technicians to create the complete function and esthetic outcome of the final prostheses.

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Conflicts of interest

The authors declare no conflicts of interest.

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