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Perspective

Relationship between the data quality of digital scans from intraoral scanners and surface topography of prepared teeth

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A key component to digital dentistry that drastically affects a clinician's ability to deliver successful restorative outcomes is the means in which data are saved and transferred. With digital technologies, data transmission from intraoral optical scanner (IOS) to milling machines or 3-D printers using computer-aided design/computer-aided manufacturing (CAD/CAM) technology plays a vital role in the accuracy of a final restoration (Fig. 1A and B).[1–3] The most common mode for transfer of these files is via standard tessellation language (STL) file formatting. STL file formatting is one of the most prevalent digital file formats because of its long performance history, universal compatibility with scanning and milling technologies, and basic topological recording principals.[4,5] Many clinicians encounter problems when using STL files when they are saved and exported. During these steps of the digital workflow options to shrink file size are commonly selected to decrease time spent saving files or expedite the file transfer process from dental clinics to external laboratories.

The STL file format emerged to store data used for mechanical part manufacturing and since has gone through little development because of its reliable and simplistic methods of design. These files are used in fields that utilize additive or subtractive manufacturing methods and range in use from the automotive and aerospace industries to now the healthcare industry. In the field of dentistry, data for STL files are generated by using laser or light emitting diode (LED) scanning IOSs to map a given objects topography. This scanned topography is then overlayed with various sized triangles or 'triangular mesh' to generate a computer model of the scanned object. The placement of these triangles is dictated by a three-dimensional Cartesian coordinate algorithm to yield the most accurate triangular representation of the scanned object. Depending on the quality of the scan, the scanners capabilities, and complexity of the object being scanned, these triangles will vary in size (Fig. 1C and D). Triangles will become smaller and more numerous in areas that are topographically

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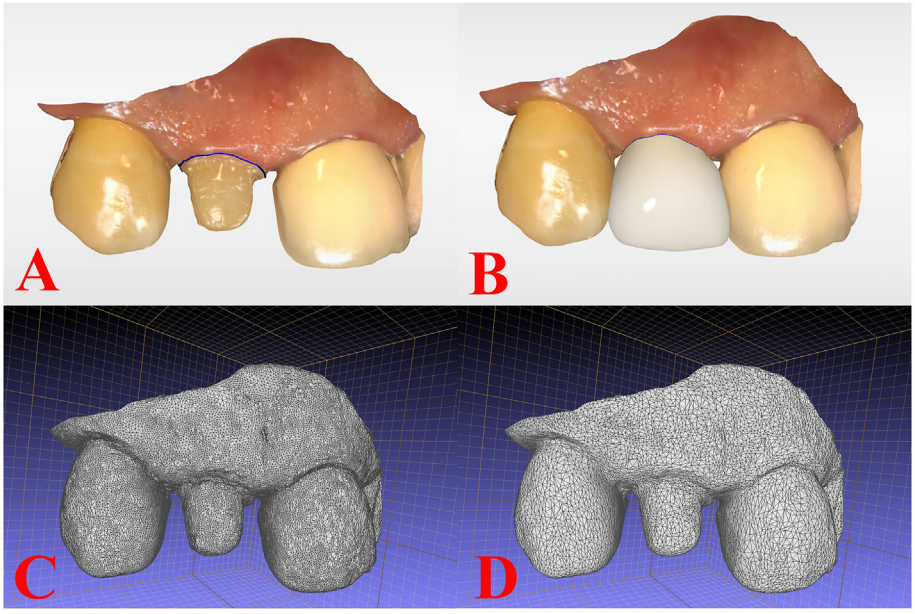

Figure 1 Digital workflow of a CAD/CAM crown. (A) Digital impression of the prepared tooth. (B) Digital design of proposed restoration. Mesh views of full-size (C) and small-size (D) STL files of the same digital impression by using a 3D mesh processing software program.

complex such as in an indentation or intricately designed surface. Areas that are more simplistic in nature and predominately flat will be represented by larger, less numerous triangles. Overall, the goal of the triangular mesh is to laminate an object's surface to produce the most accurate digital working model possible.

While STL file formatting appears complex, it is one of the simplest formats and offers many benefits to clinicians yearning to maximize the use of this technology. A major benefit is its open-source formatting which allows for many different scanners to produce an STL file and various manufacturing interfaces to construction the file. This cross-compatibility gives freedom to clinicians who desire to blend various scanning and manufacturing technologies from different companies. Other file formats are proprietary and are linked to specific products which restrict a clinician to the use of one company's 'digital ecosystem'. Another benefit to STL's simplistic design is its relatively smaller file size when compared to other data storage designs. In recent years, new file formats such as OBJ and PLY have emerged and offered advanced capabilities of quantifying color and texture of scanned objects via IOS systems.[6,7] While these additional qualities increase the accuracy of a given scan, the increase of file size effects the speed in which it can be saved and exported to outside laboratories for processing.[8]

While an STL file is in fact smaller than its competitors' file sizes, STL files are not immune to the effects of size-related complications. When clinicians save STL files, options are given to save the file in full, moderate, and small file sizes. Full size saving records the IOS's true scan, while the moderate and smaller sized files manipulate the true scan by fusing multiple triangular mesh units together to produce a larger, more generalized triangular representation of an area, thus reducing the amount of data in a given file. This manipulation and generalization becomes more oversimplified as files are compressed from a full, to moderate, to small file size. Some clinicians may choose to compress files into a smaller size to decrease the time spent saving data or the time required to send a file for manufacturing. Clinicians must consider that the shrinkage of file size decreases the resolution of surface topography scanned by a IOS. Ultimately, this leads to a less accurate reproduction of prepared tooth surface and will result in inaccurately fabricated crowns. This especially poses a problem for procedures that have a small margin for error such as the seating of long-span fixed prostheses.

With the digitization of information on the rise, it is important that users understand the fundamentals of data acquisition and file formatting to maximize the potential of digital technologies. STL files provide a versatile, accurate, and time-tested method for clinicians to store information gathered by IOSs. It must be noted that while the capabilities of this technology are impressive, its overall effectiveness is dependent on the knowledge of the user. The compression of STL files into smaller, sender-friendly formats poses a major threat to the effectiveness of restorative outcomes. Data quality of digital impressions is an essential component to restoration success and should never be compromised for faster upload or sending times.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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