What's new for the clinician?

Summaries of and excerpts from recently published papers

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1. Effects of three types of digital camera sensors on dental specialists' perception of smile esthetics: a clinical trial

Sajjadi SH, Khosravanifard B, Moazzami F, Rakhshan V, Esmaeilpour M. Journal of Prosthodontics 2016; 25: 675-81.

Facial attractiveness and aesthetics have become increasingly common reasons why patients seek dental care in today's digital world. As dental practice has become computerized, digital photo documentation has also become a standard procedure because of its numerous clinical and research advantages.[1]

The quality of an image might influence the perception of beauty. Although the main goal of dental imaging has been documentation, the general population has become more familiar with and indeed, reliant upon, digital file sharing, and hence dental practice might come to depend more and more on the quality of digital images. It is possible for clinicians to share the results of their practices with each other or with their patients. One of the concerns of patients or dentists might be the beauty of the images, regardless of the technical attributes. Patients might mostly seek aesthetic improvement, and other clinicians might judge one's work primarily based on aesthetic factors. Therefore, more appealing digital dental images might be considered a clinical advantage.

Nevertheless, it is not known whether objective camera properties might contribute to the subjective judgment of clinicians regarding facial beauty, as there is no relevant study at any level. In digital devices, many of the properties of these image may be affected by the type of digital sensor.[1] The most common types of sensors are CCD (charged coupled device) and CMOS (complementary metal–oxide–semiconductor). CCD is one of the oldest image-capture technologies for digital cameras and has long offered superior image quality compared with CMOS sensors, with better dynamic range and noise control. Although CCD is still prevalent in budget compact models, its complex design and greater power consumption have for the large part prompted camera manufacturers to preferentially choose CMOS alternatives.

CMOS has in the past been considered inferior to CCD, but today's CMOS sensors have been upgraded to match and even transcend the CCD standard. With more built-in functionality than CCDs, CMOS sensors work more efficiently, require less power, and perform better for high-speed burst modes. The sensor determines just how good the images will look and how much magnification can be applied for viewing or printing. Image quality depends not only on the size of the sensor, but also on how many millions of pixels (light-sensitive photosites) fit on it, and the size of those pixels.

It is also not known whether expertise in a specific aesthetic dental specialty might change the perception of beauty. There are no studies on the influence of camera type in general (and the sensor in particular) nor on the effect of speciality experience on the judgement of beauty. Sajjadi and colleagues (2016) reported on a study that sought to comparatively evaluate the scores of beauty as judged by 12 experts of photographs of smiles taken using cameras equipped with three different digital sensors.

MATERIALS AND METHODS

In the first phase of this clinical trial, 40 female dental students (18 to 24 years old) were evaluated to include students with balanced faces and Angle class I molar relationships. A balanced face was defined as a face looking subjectively normal (but not necessarily beautiful), with no distinguishable disharmony between its facial features, or no excessive departures from normal facial angles, ratios, or linear measurements all regarded subjectively as population norms by two experienced faculty members of the orthodontic department (an orthodontist and a dentist). Participating students needed to be in complete health, without syndromes, and not to be taking any medications.

Smile photographs were taken of posed smiles of the all the enrolled participants under standardized conditions (no makeup, natural head position, focal spot of 100mm, distance = 60mm, f/8, no flash light, standardized fluorescent light, a white background, brightness set at White Balance). The coded photographs were taken using a single 18.0-megapixel digital single-lens reflex (DSLR) camera (EOS 550D; Canon) equipped with a macro lens, and installed on a tripod. The grid visor of the camera was used to improve the accuracy in terms of the position and symmetry of the smiles within the image. The focus was set at taking the lower one-third of the face.

A panel of experts (six orthodontists, three prosthodontists, and three specialists in restorative dentistry) were asked to rank the beauty of the smiles independently. The smile

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photographs were sorted into a random order. The same order was given to all the judges. Each judge viewed each image for 20 seconds, without any rewind. They used a 100mm visual analog scale (VAS) to rate the beauty of each smile. After 2 weeks, the images were sorted in a different random order. The images were handed again to the same judges. They rated the images in exactly the same manner. The VAS scores were converted into ordinal scores 0 to 10. The rank of each image was calculated by summing up all the scores awarded by all judges in both sessions. The total ranks were used to select the 20 smiles with the highest scores.

The 20 students with the highest smile ranks were again invited for photography. Digital photographs were taken by a sixth-year dental student who was trained and calibrated by a faculty member certified and experienced in photography, who also supervised the procedures. The posed smiles of the 20 students were photographed using three different calibrated cameras (EOS 5D Mark II; EOS 550D; and PowerShot G12; Canon). A tripod (Canon) was used to ensure a similar distance of the cameras from the students. The camera frames were different, but they were equipped with similar regular lenses (100mm focal spot). The lenses of the 5D and 550D cameras were identical. The lens of the PowerShot camera differed from the other two in terms of its size and model, but was set at 100mm focal spot as well. No macro lens was used in this study. The camera configurations were calibrated and standardized for all cameras (set at manual setting, ISO=800, shutter speed = 1/125 or 1/250, flash: on, distance: 50cm, white balance setting, and f/8). The background was plain white. The natural head position was standardized by asking each student to look at her own image in the mirror placed in front of her (behind the camera).

The cameras had three different sensors:

1. Full-frame 35.8 × 23.9mm DSLR 21.1-megapixel complementary metal–oxide–semiconductor (CMOS) sensor (camera: EOS 5D Mark II, Canon)
2. Advanced Photo System type-C (APS-C) half-frame 22.3 × 14.9mm (1.6x conversion factor) DSLR 18.0-effective megapixel CMOS sensor (camera: EOS 550D, Canon)
3. Compact 7.62 × 5.59mm 10.4-megapixel charge-coupled device (CCD) sensor (camera: PowerShot G12, Canon)

The images were first sorted in a random order. The same order of images was shown to all judges. Each image was seen for 20 seconds (by the automatic slide view feature, set at 20 seconds) without rewind and without skipping any images. Each expert evaluated the beauty of the smiles on a Visual Analogue Score (VAS). The VAS was converted to 11 equal ranks (0: definitely not pleasing, 10: extremely beautiful). The same procedure was repeated two weeks later, in another (randomly chosen) order. The same random order of images was used for all judges. The average score given over the two sessions to each image was calculated. The study was double blind: the judges were blinded to the type of sensors, and the images were coded.

RESULTS

The highest average beauty score was obtained by images recorded on the 5D camera (full-frame sensor), and the lowest average beauty score was related to the G12 camera (compact sensor), which exhibited a 52% decline in the VAS score. The Kruskal-Wallis test detected a significant difference between the scores pertaining to different sensors ($p < 0.0001$). The Mann-Whitney U test indicated significant differences between the full-frame sensor and the half-frame and compact sensors (both p values < 0.01); however, the difference between the half-frame and compact sensors was not significant ($p > 0.1$). The scores given by each group of specialists were close together and not significantly different according to the Kruskal-Wallis test ($p = 0.7$). The two-way ANOVA exhibited a significant difference between the sensors ($p < 0.00001$); however, the differences between the scores of the specialties ($p = 0.687$), and the interactions of the variables “specialty and sensor” ($p = 0.894$) were nonsignificant.

CONCLUSIONS

The results of this study suggested that sensor resolutions and qualities might affect the subjective judgment of smile beauty. The full-frame sensor of 21.1-megapixels might result in more appealing images and higher consistencies in the perception of beauty. The results of half-frame 18.0-megapixel and compact 10.4-megapixel sensors might not necessarily differ in terms of subjective smile attractiveness. Dentists of different specialties (orthodontics, prosthodontics, and restorative dentistry) might have similar subjective judgments of smile beauty.

IMPLICATIONS FOR PRACTICE

This study revealed for the first time that some types of digital sensors (and some levels of image quality) might affect the perception of beauty as assessed on a digital photograph. Clinicians should take the advantages versus limitations of each sensor (and camera) into consideration when purchasing a camera. If perception of beauty is an important variable, it might be recommended to use the full-frame sensor, judged best among these three assessed sensors.

Given the very close results of the three specialties, it might be concluded that different dental fields have similar esthetic standards, which might be favourable in multidisciplinary tasks

Reference

1. Sajjadi SH, Khosravanifard B, Moazzami F, Rakhshan V, Esmaeilpour M. Effects of three types of digital camera sensors on dental specialists’ perception of smile aesthetics: a preliminary double-blind clinical trial. Journal of Prosthodontics 2016; 25: 675-81.

2. Fitting accuracy of zirconia single crowns produced via digital and conventional impressions—a clinical comparative study

Rödiger M, Heinitz A, Bürgers R, Rinke S. Clinical Oral Investigations 2017; 21: 579–87

As Dentistry moves into the digital age, computer-assisted design/computer-assisted manufacturing (CAD/CAM) of dental restorations is becoming a common feature of many dental practices and teaching/training institutions today. Currently, most of the systems allow for the digitizing of whole quadrants and jaws and additional scanning and correlation of antagonistic teeth. The potential benefits of these intraoral scanning (IS) processes are an improved patient- and operator-acceptance and potential cost- and time-effectiveness.[1]

The first generation of IS systems required the application of a scanning powder. More recently introduced technologies based on confocal imaging have no such requirement. This simplifies the clinical handling but might affect the accuracy of the scanning results as the powder layer is omitted. Clinical data on these "powder free" intraoral scanners are still sparse.[1] Moreover, the precision of a IS can be influenced by several factors, including the finishing line location, moisture control, and patient compliance or scanning strategies.[1] Intraoral scans, especially in the molar area where only limited space is available, are challenging. In these areas, the oral cavity limits the handling of the so-called scanning wand. Furthermore, moisture control in these areas is more challenging than in the anterior region.[1]

As all IS systems can scan only visible and dry areas, this is of high practical relevance, because scanning accuracy may be affected.

Conventional impression (CI) taking with reversible or irreversible elastic impression materials is still a widely used method for generating an exact replica of the intraoral situation and transferring this information to the dental laboratory as the basis for the fabrication of indirect dental restorations. For both methods (CI & IS), the precision of marginal fit and the internal fitting accuracy of the fabricated dental restorations are crucial factors in determining the clinical long-term success. An insufficient marginal fit can lead to plaque retention and washout of the luting agent, allowing secondary caries, periodontal, and pulpal inflammation or retention loss of the restoration.[1] Additionally, the consequences of an insufficient internal fit could result in a loss of axial retention, missing rotation stability, and reduced fracture toughness.[1]

Although there is some controversy regarding the clinically acceptable marginal gap, most authors have accepted a maximum marginal gap of 120 μm as the minimum clinically acceptable standard.[1] Rödiger and colleagues (2017)[1] reported on a prospective clinical study which sought to evaluate the marginal and internal fit of zirconia molar crown copings manufactured with conventional and intraoral digital impression techniques using a replica technique. The null hypothesis was that the zirconia copings based on digital impression taking would offer statistically significant better marginal and internal accuracy than copings produced via conventional impression taking.

ACRONYMS

CAD/CAM: computer-assisted design/computer-assisted manufacturing
CI: Conventional impression
IS: intraoral scanning

MATERIALS AND METHODS

Twenty patients who met the following inclusion criteria were accepted into this study: they were of legal age and in need of at least one single crown (free from clinical symptoms) in the molar region; the tooth had a visible finishing line not more than 1mm below the gingival margin and patients had an adequate level of oral hygiene expressed by the absence of bleeding on probing and a periodontal pocket probing depth of <4mm. Two restorations in each patient per abutment were manufactured—one coping via conventional impression (CI) and one via digital intraoral scanning (IS). All patients received a fitting of copings with the assessment of internal and marginal fit using a replica technique. Thus, 20 specimens per group were evaluated. After the evaluation of clinical fit, the framework that offered the best accuracy was veneered and inserted.

In terms of tooth preparation, all abutment teeth received an adhesive core built-up with a self-curing using an adhesive system (OptiBond). The preparation was performed under local anesthesia with the objective of getting a 90° chamfer finish line with a circumferential reduction of 1.0mm and an occlusal reduction of 1.5mm. The convergence angle was set at approximately 6°–10°, and all edges were rounded. After preparation, the teeth received a provisional restoration fabricated from an auto-curing resin-based material. Impressions were taken after a minimum waiting time of 7 days to allow complete healing of the soft tissues. Before taking digital and conventional impressions, retraction cords were applied using the double-cord technique for rendering of the finish line.

Prior to the conventional impression taking, the digital intraoral scan using the cara TRIOS system (Heraeus Kulzer, Hanau, Germany) was performed. No powder application was required for this system. The resulting digital data set was directly transferred to a CAD software digital design of the zirconia copings. Additionally, a working model based on this data set was printed by scan LED technology using a light-curing resin. According to the manufacturers' information, the models were fabricated with a layer thickness of 50 μm and a lateral resolution (edge length of a pixel) of 32 μm. This model was used for the manual adjustments of the copings before the clinical fitting.

For conventional impressions, a one-step putty-wash technique with a polyvinylsiloxane material (Aquasil Monophase + Aquasil XLV) was used according to the manufacturer's instructions. To improve the accuracy of the impression, custom impression trays based on study models were implemented. The antagonist arch impression was taken using an alginate material (Blueprint).

To create a data set for the digital design (CAD) of the zirconia copings, the impressions were used to fabricate stone models for indirect digitalization via a model scanner (3shape D700, cara TRIOS).

All copings for both groups (CI and IS) were designed by the same experienced dental master technician using the same software (Dental Designer 2014). All restorations were designed and manufactured using the same settings and following the manufacturer's recommendations (cement spacer, 40 µm, minimum wall thickness, 500 µm, edge reinforcement, 200 µm.

To assess the clinical accuracy of the copings regarding marginal and internal fit, the inner surfaces of the copings were coated with a white-coloured low-viscosity silicone (Coltex) before seating it on the respective abutment with maximum finger pressure for 10 s. After 4 min, the copings were carefully removed, and to stabilize the adherent thin white silicone film, the crowns were filled with a more rigid orange-colored silicone (Aquasil) to obtain a good contrast for the discrimination of the different layers. Then, the silicone replica was carefully removed from the coping for further processing.

In addition to the undercoating of the white silicone layer representing the marginal and internal gap with the orange silicone (replacing the abutment), a custom-made box was used to cover the replica specimens with a blue-coloured silicone (Aquasil), thus replacing the framework. This box was designed to ensure that the position of all specimens was exactly centralized in the encasing blue (opaque) silicone layer, with all specimens having the same mesio-distal orientation. This allowed for sectioning into four pieces (respectively the measurement locations) of each specimen in the mesio-distal and bucco-oral direction in a reproducible and comparable manner. The four sections of each specimen were used for measuring the internal and marginal gaps by one calibrated examiner. Two sides of each section (mesio-distal and bucco-oral) were evaluated at six points for internal gap (ca = chamfer area, aw = axial wall, aw min = axial wall minimum discrepancy, aw max = axial wall maximum discrepancy, aot = axio-occlusal transition area, oa = occlusal area) and at two points for marginal gap (mg = marginal gap, absol mg = absolute marginal gap. Replica film thickness was measured on digital photographs captured by the integrated camera of a light microscope with a magnification factor of ×35 and a special measuring software after calibration.

RESULTS

When comparing both groups (CI vs. IS), only two locations revealed significantly better internal accuracy for IS: "chamfer area" (ca) (117.94 ± 74.21 µm vs. 147.88 ± 63.88 µm) and "occlusal area" (oa) (164.22 ± 73.17 µm vs. 207.60 ± 69.99 µm) ($p \leq 0.05$). The lowest values for internal accuracy in both groups was found at the axial wall (aw min) (CI 43.36 ± 36.98 µm, IS 34.79 ± 28.67 µm), whereas the poorest fit could be found in the "occlusal area" (oa) for the CI group (207.60 ± 69.99 µm) and in the "axio-occlusal transition area" (aot) for the IS group (187.17 ± 77.35 µm).

When comparing the values of the CI group and IS group, no significant differences could be demonstrated regarding marginal accuracy (CI 82.17 ± 75.17/IS: 87.4 ± 91.2)

CONCLUSIONS

The researchers concluded that the CAD/CAM-fabricated single tooth restorations in the posterior region produced by an intraoral scanning system using confocal imaging offered a comparable, or even better, precision of marginal and internal fitting accuracy than restorations based on conventional impressions in combination with the laboratory scanning technique.

IMPLICATIONS FOR PRACTICE

The study results suggest that the complete digital workflow including a digital impression technique can be rated a suitable alternative for conventional impressions, followed by a lab-side digitization, and a CAD/CAM manufacturing process in indications where the preparation limit is visible and only slightly subgingival. The conventional impression method however remains the "gold standard" as the crowns produced using this technique are still within the clinically acceptable marginal gap limit of 120 µm. Additionally, the authors of this study have highlighted the use of digital technology within certain clinical parameters to ensure clinical success.

Reference

1. Rödiger M, Heinitz A, Bürgers R, Rinke S. Fitting accuracy of zirconia single crowns produced via digital and conventional impressions—a clinical comparative study. Clinical Oral Investigations 2017; 21: 579–87