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review

DENTAL PHOTOGRAPHY TODAY. PART 1: BASIC CONCEPTS

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SUMMARY
This paper is the first article in a new series on digital dental photography.
Part 1 defines the aims and objectives of dental photography for examination, diagnosis and treatment planning, legal and forensic documentation, publishing, education, marketing and communication with patients, dental team members, colleagues and dental laboratory.

Key words: digital dental photography, legal documentation, forensic documentation, publishing, education, communication.

Introduction

There are many reasons for using dental photography today; the primary purpose of digital dental photography is recording accurately the clinical manifestations of the oral cavity. As a spin-off, secondary uses include legal documentation, publishing, education, communication with patients, dental team members, colleagues and technicians, and finally marketing. Each of these uses enhances and elevates the status of dental practice as well as improves delivery of care to patients (1).

A correct color rendition and a sufficient resolution, to record both soft and hard tissue details, are two essential features for a useful dental image.

The first item to consider is color rendition. It is fundamental that a dental image precisely records the color that is perceived by the eyes during dental examination. Accurate color rendition is possible, but is not always easy to achieve.

It is also important to be sure to get accurate white balance. White balance is the process of removing unrealistic colorcasts from photos. Many digital cameras have the ability to do a manual white balance on the camera, which is achieved by shooting a specially made target that is guaranteed to be very close to a neutral color.

In Part 2 we will illustrate the importance of white balance, color temperature and color rendering; in fact it is very important to understand that eliminating the influence of different light sources, the image should faithfully reproduce the color of gingivae, oral mucosa, teeth and any prostheses as they appear in the mouth.

Why is so important a correct color rendition of soft and hard tissues?

Concerning soft tissues, a correct color rendition is an excellent method for distinguishing between healthy and diseased tissues and for recording pathological changes such as white patches, inflammation, ulceration, burns, lacerations, carcinoma, etc. (Figure 1 a, b).

Similarly, a correct color rendition of hard tissues reveals enamel translucency, decay, erosion and abrasion, as well as cervical dentine exposure and sclerosis (2) (Figure 2 a, b).

The other item to consider is the quality of the images, which results from the resolution of the

Figure 1 a, b
a An incorrect color saturation makes it difficult to evaluate a soft tissue lesion.
b A correct color rendition allows a better diagnosis.

Figure 2 a, b
a An incorrect color rendition hides lesions on hard tissues.
b A correct color rendition allows the diagnosis of the same lesions.

sensor and the ability to capture the finest details by lenses. The bottom line is that resolution equals information: the higher resolution means more image information. Recording details is important for examination, diagnosis, treatment planning and assessing outcomes of therapy for many disciplines such as aesthetic dentistry, implant dentistry, oral surgery, orthodontics and periodontics. As already mentioned, it is also crucial for a legal record of clinical situation. In fact, if the resultant image lacks in realistic color, fine details and resolution, it serves little clinical purpose just like a poor quality radiograph.

Examination, diagnosis, treatment planning

The primary use of dental photography is certainly to assist the operator on the initial examination of the patient, to help him in the diagnosis and control of the medical care outcome over time. So dental photography must be considered as a diagnostic tool, similarly to X-rays, or other tests and investigations. During a first examination, the operator could not see many details, and

photography is an effective method, as a real second visit, to analyze the preoperative dental status at a later date. So a complete set of oral images, collected on first examination, is valuable to get to a certain diagnosis, to provide dental treatment options and is not only useful for recording a baseline of oral health.

Developmental defects of enamel (DDE) are visible deviations from the normal appearance of tooth enamel caused by enamel organ dysfunction, and they are one of the lesions diagnosable through photography.

The accurate recording of DDE is important for diagnostic, clinical, and medico-legal purposes, as well as for etiological studies (3, 4). Chen et al., in a longitudinal study to assess risk factors for early childhood caries, on two groups of 138 and 238 infants, used a quick photographic technique compared to clinical examination. Cheeks and lips were simply retracted by examiner's finger to expose the anterior teeth and part of the upper and lower gums. The study showed that the photographic method detects more DDE compared with clinical examinations (5). Golkari et al. in a study on 110 schoolchildren concluded that photographic method was much more sensitive than direct clinical examination and replication methods with additional-curing silicon material in detecting DDE (6). Intraoral photography shows advantages also in the caries detection and in dental epidemiological studies in children.

Boye et al. in two different studies concluded that photographic assessment method is comparable to the visual examination method in the primary dentition, with the additional benefits of archiving, remote scoring, allowing multiple scorers to evaluate images and enabling longitudinal analysis (7, 8). Pinto et al. arrived at the same conclusions for dental trauma. The photographic assessment method of dental trauma was valid and reliable as compared to the oral clinical examination (9).

Versatility and reliability of the method opens the doors to important applications. Tele-health has been considered as a practical and potentially cost-effective method of providing healthcare to large community of preschool children or underprivileged population. Adolescent inmates for example could benefit from oral health screening using digital photography. Tele-dentistry appears to be a reliable alternative to the traditional oral examination for dental caries assessment (10). Clearly, extra and intra-oral photographs are an important diagnostic technique in orthodontics, also used during therapy to evaluate the progress of the treatment plan. The move to digital photography offers many advantages to orthodontists. High quality photographic documentation is almost routinely taken throughout treatment with little direct cost to the clinician (11). A survey of the members of the Angle Society of Europe showed that 60% of orthodontists took their own clinical photographs, 35% assigned the task to an auxiliary, and 5% hired professional clinical photographers. Sandler et al. showed that most of the photos taken by the 3 groups of photographers were judged to be good or acceptable. Orthodontists rather produced significantly more good-quality intraoral photographs than others (12).

Indeed, it is not difficult to learn correct photographic techniques after a normal learning curve. In the same way a photographic record is useful in further cases in addition to those already mentioned like analysis of facial profiles and orthodontic tooth alignment (13), to assess occlusal disharmonies, to evaluate prosthetic rehabilitation or gingival health and periodontal pocket or even ridge morphology prior to implant placement. Pictures provide an improved documentation and the option of monitoring particular situations over longer periods of time.

Legal aspects

Digital photography is an important tool in dentistry, especially for the so called legal aspects. It is possible to identify two main kinds of legally-relevant dental photographic documentation:

- the legal documentation, intended as photographic images documenting pretreatment

conditions as well as aesthetic changes that were achieved through delivery of dental care;
- the forensic documentation, including the identification of human remains and the analysis of dental-related trauma, such as human bite marks (14).

Legal documentation

During the last decades the number of trials involving dental practitioners is dramatically increasing. Plaster models and radiographs do not adequately communicate appearance to non-dental professionals (15).
Besides to now digital cameras are much easier to use, in terms of both making and storing the photographic images. For the over mentioned reasons it is illogical to avoid recording potentially legally threatening clinical situations and storing them in digital form for documentation needs. It is worthless to say that when photographic documentation of the specific clinical situation under question is available, the dentist's case is much easier to defend (16). Furthermore, the purpose of the photographic documentation is necessary not only to legally protect the dentist, but the patient as well. In fact, potential discrepancies between the dentist and patient may also be overcome in this way (17).
It should be reasonable to document all the dental procedures carried out, but at the same time it is quite comprehensible that the common practitioner is not going to document with pictures the daily routine procedures for a matter of time and laziness. That is why it is possible to select which procedures are likely to be documented for a legal purpose. Usually surgical treatments as well as aesthetic treatments are recommended to be proved with pictures. Furthermore, photographs should be taken of patients who appear to be suspicious or overly anxious about the treatment they have agreed to receive, or who have had previous legal activity with a dentist. Even comprehensive and expensive dentistry should be documented (16).
At least the starting and ending conditions in such procedures should be documented, as well as any peculiar occurrences during treatment (16). In today's medical/legal environment, a pre-treatment/post-treatment series of photographs is imperative (15). Having this material available it is always possible to prove the starting oral situation of the patient and the consequent changes due to the dentist decisions and therapies.

Forensic documentation

Forensic dentistry refers to the application of dental science, especially through photographic documentation, to legal matters. The forensic dentist most usually assists in identifying human remains. Less often, the processing and analyzing of bite marks or dental-related trauma for court evidence become necessary. In each case, evidence must be preserved, particularly since the specimen will be available for a short time before decomposition, burial, or healing occurs (18). The photograph is often a vital aid in accurate documentation of perishable evidence (19).
Identifying unknown human remains by dental sciences is second in effectiveness only to fingerprints. The validity and reliability of the method are based on the numerous combinations and permutations in the patterns of decayed, missing, or filled teeth.
Human bite marks in skin occasionally accompany homicides, sexual assault, and child abuse. Rarely, a perpetrator may be bitten in self-defense by a victim (18). Accurate recording of all aspects of the mark before healing or decomposition obliterates the evidence. The size, shape, color, depth of indentations, and three-dimensional contour should be preserved. No one medium is suitable for all these functions. Photographs can record the first three, whereas dental impressions show the last two (18).
All photographs intended as evidence should be labelled with the location, date, time, subject, and

photographer's name and may include such information as camera, lens, film, lens aperture, subject distance, shutter speed, or flash setting used (18).

Publishing and education

During the last decades the application of digital dental photography for publishing and education has become essential. Nowadays the clinician needs also photographic skills in order to show his/her cases to the scientific community, to colleagues and to students (20). It should be necessary to capture images of each step of the dental procedure accomplished, so that a consecutive image selection could be possible. At the same time is relevant to take pictures also at every future patient control to record possible changes due to the treatment carried out or to other variables such as time.

As anticipated, pictures are essential in the field of education, enabling the student to have a clear image of the topic explained. That is a great advantage in the diagnostic step. In fact, having watched images of a lecture or from a book will enable the student to recognize more easily some lesions and pathological conditions of the oral cavity. At the same time pictures describing the workflow of a particular treatment could help the student in having a clear vision of the passages necessary to carry out the treatment itself. Besides, with the photography it is possible to highlight small details. Up to now the most common way of doing education is through presentations, which are supplied with plenty of pictures and videos. So after taking pictures and storing them, an accurate editing is essential to create clear and explicative presentations. Before proceeding to the presentation editing, pictures should be analyzed and if necessary refined. That is possible through specific computer tools included in all the picture visualization programs. These tools allow the clinician to rotate, zoom, cut-and-paste, change the color characteristics, as well as include special effects. Once the pictures have been refined, it is possible to edit a slide presentation. The two most common used slide presentation programs are Keynote for Mac, and PowerPoint for Windows (20).

As for the education, pictures cover a fundamental role in publishing, intended as research articles and books. The reasons are nearly the same, as pictures help the lecturer in understanding the text and effectively visualize what the written passage is about. A great amount of research material could be gained from the images of treatment accomplished, always noting the date of treatment and any peculiar information that may relate to the functional longevity or the long-term aesthetic acceptability of the treatment (16). The images collection is quite fast, but what it takes longer is the pictures to be scheduled and categorized in the computer. Anyway it is worthwhile to spend time and patience in that way in order to have the treatments documentation easily reachable for future needs (16).

Communication

Patient

Effective communication skills are essential for all dental professionals, and digital dental photography is an exceptional tool for communication and documentation. Many stock images or animations of teeth and dental practice can be obtained from a dental library, dental software, internet downloads, but it is preferable to use patient clinical pictures in order to enhance confidence.

A photographic clinical sequence may explain the complexities of advanced treatments, and also helps to justify the costs involved. A verbal explanation of dental diseases, their etiology, prevention and therapy may be confusing or even daunting for a patient, not accustomed to a technical medical language; when an image is included it can be elucidating and has a different and lasting impact. One of the branches that more benefits from a good degree of communication is certainly periodontics, for the need of

patient motivation to maintain the results obtained through therapy, or in preventive periodontics. Visual messages are much more effective than only verbal ones. Showing pictures ranging from the starting status of disease to the health status, achieved through the therapies, leaves an ever-lasting impression, informing the patient of the potential hazards of this disease. Generally intraoral conditions, which in the course of dental treatment are subjected to change, can be recorded in detail by means of photography. A dental office that will begin to collect photographs of the treatments carried out, in a short time will have a real library able to thoroughly describe all possible treatments provided. The library can be used for the illustration of therapeutic plan and related costs, and for the purpose of education and motivation of the patient. With the proper training, techniques, equipment, and implementation, dental photography can significantly enhance the level of treatment provided (21).

Staff/Colleagues

The entire dental clinical and office staff can visually explain the therapy to execute, eventual critics points of therapy or maintenance.
At the same time dental team can also benefit from seeing treatment sequences in order to plan the treatment shared among many specialist dentists, ensuring a better workflow and common work protocols.

External specialists

Sending images to a specialist for further diagnosis, treatment or a second opinion via email attachments, dropbox or via pen drive, CD or DVD, allows a good amount of information, beyond those descriptive. This is time saving, especially in important conditions like in the case of suspected pre-cancerous or malignant lesions, allowing a first visit in near real time.

Academic

Photography is a key part of academic in many ways. It is important to prepare university lectures, conferences or poster presentations, and to publish postgraduate books or articles. In particular, many dental journals show strict publishing criteria for images.

Dental technician

One of the major challenges facing the dental technician and dental clinician is the lack of interaction and communication. This is particularly relevant to aesthetic dentistry, which must also include the communication to transfer patients' wishes and expectations directly to the ceramist. In order to obtain the best possible results in prosthetics it is important to forward images of all stages of treatment to the dental technician. Notes and comments can be sent with photos to communicate key features such as color, shape, alignment, characterizations, regions of translucency, etc. If it is not possible to plan the try-in stage with the dental technician, taking pictures in this case allows the ceramist to visualize the prosthesis *in situ* in relation to soft and hard tissues. Standardized high quality photographs are also an advantage when the shade is taken for a direct restoration – for example a direct veneer or a class IV. In this case a picture can really help the clinician identify the opalescent areas and the halo effect of the adjacent tooth, before re-doing the restoration (22).

Marketing

The last purpose of dental photography that we will consider is for internal or external marketing. Internal marketing relies on team members motivating patients to refer friends and family. If the team lacks sufficient verbal skills, provides only average customer service, or does not build

strong relationships with patients, then any attempts at internal marketing will likely fail.
So, the first step for internal marketing does not start with marketing, but it begins with interpersonal relations.
Interpersonal relations include: how the phone is answered, how patients are greeted, the way that hygienists and dentists relate to and educate patients, and how the front desk personnel interact with patients during check-in and check-out.
Just when a practice provides a uniquely positive patient experience based on strong interpersonal skills, patients feel comfortable referring their friends and family.
So stationary like letterheads, appointment cards, estimate forms, post-operative instructions and business cards, all with images or logo, become useless without good interpersonal relations.
The choice of images in brochure or showed on interior monitors is a matter of personal taste and can include pictures of the entire practice team, the outdoor view of the premises, reception area, treatment and sterility rooms, always including a smiling staff member, rather than an empty room, which is perceived as isolated and cold.
Clinical images of "before" and "after" or sequences showing stages of particular treatments such as crowns, fillings and implants can be useful. If clinical images are included, it is important to avoid imagery that is gruesome or off-putting to a patient. Images of surgical procedures, inflammations or hemorrhages are a few examples that obviously warrant exclusion (1).
External marketing is used to obtain a high visibility to a large number of people, personalized connectivity with potential clients and personal image enhancement and self-promotion.
The importance of digital marketing is increasing every day.
Advertising in telephone directories, local televisions, newspapers or radio and television is not obsolete, but probably the most effective method today is by using the Internet.
Around 3.6 billion people are connected to the Internet on their phones. In Europe, the density of mobile users and social media users is incredibly high with many prospective customers for dentists. Dental practices can target this group by using digital marketing to their advantage.
E-mail remains a significantly more effective way to acquire customers than social media, nearly 40 times that of Facebook and Twitter combined. In US 91% of all consumers still use e-mail daily, and the rate at which e-mails prompt purchases is not only estimated to be at least three times that of social media, but the average order value is also 17% higher (23).
Also the social media networks such as Facebook, Twitter, Google Plus and LinkedIn present an extraordinary marketing opportunity for dentists. Potential patients are increasingly embracing social networks, as an integral part of their everyday lives and the interesting part is that the phenomenon is no longer restricted to the young.
The power of images in digital communication in all these ways is implied.

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