OVERVIEW

Clinical Photography in the Orthodontic Office

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(Editor's Note: In this quarterly column, JCO provides an overview of a clinical topic of interest to orthodontists. Contributions and suggestions for future subjects are welcome.)

Clinical photographs are an essential component of orthodontic diagnosis and treatment planning. High-quality photographs allow the clinician to evaluate both the skeletal tissues and the soft-tissue drape. Photos are also used for patient consultations, assessment of treatment progress, discussion with colleagues, training of staff and students, professional presentations, and publication.

To make the proper camera adjustments for various clinical scenarios and lighting conditions, the photographer must have a working familiarity with the camera and related equipment. This article covers the basics of clinical photography, the operation of digital cameras, and solutions to common problems (Table 1).

Digital Cameras

There are two main types of digital cameras.[1] Compact "point-and-shoot" models will not produce the type and quality of photographs needed in a clinical setting. Dental photography requires the use of a digital single-lens reflex (SLR) camera, which has the same basic design and capabilities as its 35mm-film-based counterpart.

An SLR allows manual focus control and can accommodate a variety of lenses, including telephoto and wide-angle. A telephoto lens with a


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TABLE 1
COMMON PROBLEMS AND SOLUTIONS IN CLINICAL PHOTOGRAPHY

Problem	Solution
Colors and hues do not match the clinical situation—e.g., mucosa appears red in photographs when it is actually pink (Fig. 1).	• Adjust the white balance setting.[2] • Use a "fluorescent lighting" setting with flash mode if the room has fluorescent lights. • Customize the color by adjusting saturation and hue settings.
Teeth look too white (Fig. 2).	• Change the exposure by adjusting aperture and shutter speed.
Some teeth out of focus (small depth of field) in frontal shot (Fig. 3).	• Focus on the distal surfaces of the lateral incisors. Use an aperture of at least f-16, or as much as f-32 for close-up work where depth is important.[3]
Reflection or double image when using mirrors for indirect photographs (Fig. 4).	• Use a front-silvered mirror or a circular polarizing filter, which allows the light to pass through from only a certain direction, cutting and diffusing all other light.[2]
Shadowing of patient's profile on background.	• Switch off the part of the ring flash that throws the shadow in front of the subject. If using a side-mounted flash, rotate the camera 180° so that the flash throws the shadow behind the patient's profile.[4]

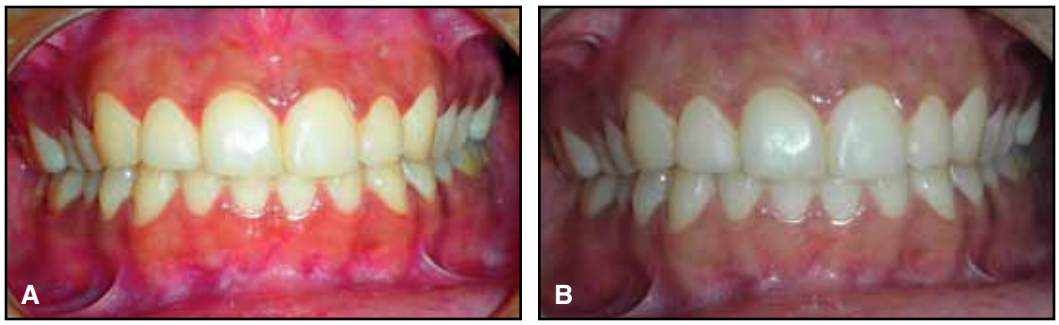

Fig. 1 Intraoral photo showing excessive (A) and inadequate (B) hues.

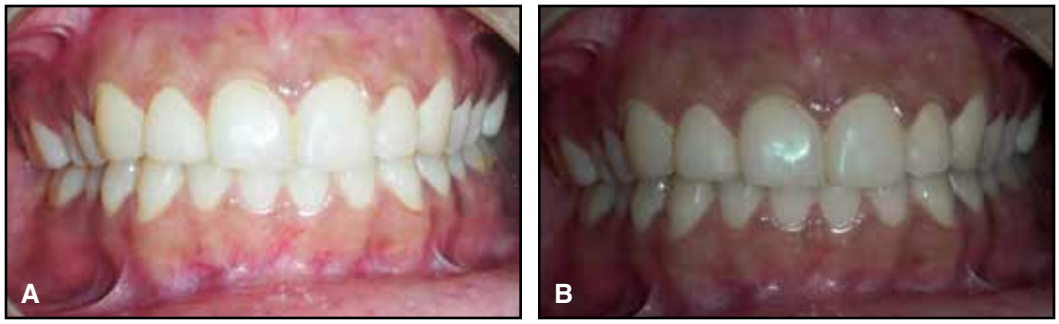

Fig. 2 Same photograph with brightness increased (A) and reduced (B).

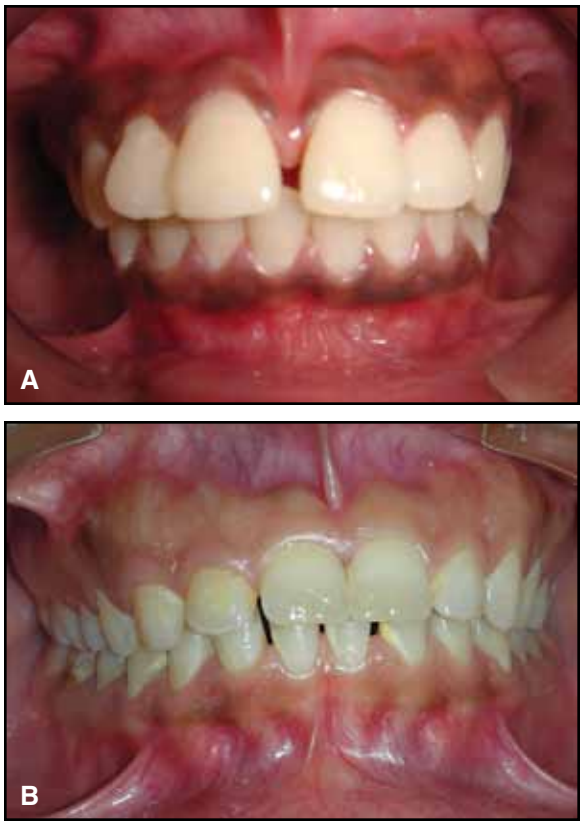

Fig. 3 Inadequate (A) and optimum (B) depths of field.

Fig. 4 Double image in photograph taken with back-silvered mirror.

100mm focal length is optimal for taking intraoral photos and can also be used for facial photos. The digital SLR employs image sensors to detect light coming through the lens and translate it into electronic signals. Image quality depends on the sensitivity of the image sensor, the camera's settings, and the image-processing engine.

Published comparisons of various digital cameras for orthodontic use suggest that with a few adjustments, virtually any digital SLR can produce excellent photographs.[4] Still, high-quality intraoral photography depends on a satisfactory depth of field and good illumination. Automatic through-the-lens (TTL) metering is recommended to achieve these objectives, along with a macro-lens and macro-flash.

Exposure Settings

Today's digital cameras automatically calculate exposure. The light meter built into a digital SLR reads the light reflected off a subject and is calibrated for 18% reflectivity—about the same level as our skin—making the automatic settings ideal for taking pictures of people under normal lighting circumstances. To take the best possible shot, however, you may need to control the settings manually.

Shutter speed refers to the length of time during which the shutter is open, expressed as a fraction of a second ($\frac{1}{500}$ is a faster shutter speed than $\frac{1}{250}$). Faster shutter speeds freeze the action because there is less chance for the camera to move. Good photography requires a balance between shutter speed and *aperture*, the opening that controls the amount of light entering the lens. Aperture size is measured in "f-numbers" and increases (meaning more light will reach the image sensor) as the f-number decreases. In other words, "f-22" denotes a small aperture and "f-4.5" a large aperture.

Depth of field is the amount of a subject that appears sharp in front of or behind the principal plane of focus. Increasing the aperture size reduces the depth of field, and vice versa. Therefore, when taking an intraoral frontal shot that requires a large depth of field—as when you want all the

TABLE 2
RECOMMENDED EXPOSURE SETTINGS FOR CLINICAL PHOTOGRAPHY

Shutter speed	1/125
Aperture for extraoral photographs	f-8 to f-11
Aperture for intraoral photographs, direct view	f-32
Aperture for intraoral photographs, mirror view	f-19 to f-16
ISO	100
Exposure mode	Aperture Priority or Manual

teeth from incisors to molars in focus—you should use a small aperture, such as f-32 (Table 2). An aperture this small does require a powerful flash to capture the details. In buccal and occlusal shots, provided the subject is correctly positioned and retractors are appropriately used, the subject area is all on one plane, so that depth of field should not be an issue. For mirror shots, since light is being reflected indirectly to the camera, a slightly larger aperture, such as f-19, is required. For extraoral photography, if the room lighting is too bright, you should reduce the aperture size; if the room is too dark, increase the aperture size.

The Photography Area

The size of the area devoted to clinical photography in the office will not affect image quality, but it can determine the type of photography and the range of lighting effects that will be possible. A dedicated photography room can be as small as about 13 × 20 feet, with a 13-foot ceiling. The main advantage of a large room is the absence of reflected light, especially from the ceiling. Compensation for secondary, reflected light requires proper placement of artificial lighting.[5] Most important is to allow enough space between the patient and the backdrop for any lighting that may be needed.

A cluttered background will distract the viewer from the subject and thus can affect the evaluation of a photograph. Although many different colors have been suggested,[3,5-7] we believe the best backdrop is white, with lights placed carefully so that no shadows are produced.

Light Management

Appropriate lighting is imperative for high-quality photography. Three types of electronic flash systems are available for use with digital SLRs:
A point flash is a single strobe-light source mounted on one side of the camera lens. The flash can be moved around the lens to provide directional lighting from different angles. For frontal, right lateral, and left lateral views, a point flash should be placed at the 12, 9, and 3 o'clock positions, respectively. This type of flash system requires considerable experience and additional setup time to maneuver the lighting direction before each exposure.
A ring flash is the universal flash system for general macrophotography. In this configuration, either a single ring-flash tube or individual flash tubes surround the lens and thus the optical axis. "Speed lights" are small strobe lights, separate from the camera body, that can be aimed in various directions. The ring flash is usually placed just in front of the lens, so that the specular (mirror-like) reflection created by the flash will eliminate shadows in the image. The main advantage of this system is that objects in the oral cavity can be evenly illuminated without shadows. The disadvantage of eliminating shadows is that an image may appear to "flatten out", with less discernible contours.
A twin flash consists of two units mounted next to the lens. In one configuration, two fixed strobes are mounted in stationary positions on either side of the lens; although this system looks like a ring flash, the light is emitted only from two vertically aligned tubes, with none coming from the top or bottom. The second design uses two strobes mounted farther from the lens on moveable arms, which can be positioned as desired on a circular mounting bracket. A twin flash may be the best system for orthodontic use because it not only offers soft, uniform illumination, but simultane-

ously reveals surface details, color transitions, translucency variations, and crack lines.

Lighting in a Dedicated Photography Room

If the photographic room or space provides natural, even light falling on the subject from both sides, flash lighting may not always be needed. Of course, natural light is not the same throughout the day or in all seasons, so artificial lighting will be required to standardize conditions.

For orthodontic photography, artificial lighting is commonly managed with a ring flash or twin flash. The light can be diffused with either a soft box or an umbrella light (Fig. 5). Soft boxes typically provide softer light than umbrellas due to their multiple diffusion layers, allowing them to be positioned closer to the patient.[6-13]

Here are four possible configurations of studio lighting equipment:

1. A single professional flash, ceiling-mounted on a straight rail parallel to the background panel. A small, rectangular reflecting panel (14" × 28") can be held horizontally at the patient's chest, just under the collarbone, to prevent shadows. Aluminum foil glued to a piece of cardboard can also be used as a reflector.
2. A single soft box and a 250-watt photoflood placed in front of the subject, augmented by window light.[9]
3. A single soft box placed at a 45° angle to the patient and a fill light (a lower-power flash unit that counteracts the shadow from the main light source).[10]
4. Two or more flash units at 45° angles to the subject, used in combination with two additional back lights,[6] also at 45° angles, to eliminate shadows in the background. An illuminator (similar to a view box for radiographs) can be used in place of the back lights. The key is the 45° angle, which preserves the three-dimensionality of the image.

Many cameras come equipped with built-in slave units that will trip separate flashes without direct wire connections, thus reducing clutter in your studio.

The distance of the flash unit from the background may be fixed at about five feet, with the patient seated about three and a half feet away for photography with a single professional flash. Some authors suggest positioning the subject about five feet in front of the background and directly in front of the camera to avoid shadows.[8] If an illuminator is used to eliminate shadows, the patient can be positioned closer to the background. In natural-

Fig. 5 A. Soft boxes. B. Umbrella light.

Fig. 6 Complete extraoral photography series (submental view generally required only in special cases).

light conditions, the patient should be far enough from the background that the shadow is thrown at a distance.

Lighting in a Photography Area

In a small office, a portion of the clinic can be devoted to photography. A painted wall will suffice as a background, as long as it is flat and free of distractions such as pictures, windows, and electric fixtures. A custom-sized, motorized, light-blocking shade can be used to create a backdrop in front of a window, or a white roll-up screen can serve as an instant plain background.

Because the main objectives are to ensure uniform lighting of the patient's face and to avoid shadows, any external source of bright light, such as sunlight from a window, should be shaded. Overhead lights need not be switched off if their light is soft and falls uniformly on the patient. Without wall-mounted lights or soft boxes, the lighting must be managed with flash units on the camera.

The best solution is to use more than one light source: one key light of higher power that will bounce from the front of the patient and one fill light of lower power to take care of the shadows. For the fill light, bounce the external flash off the ceiling so that it reflects on the subject. If the ceiling in the photo area is too high, an artificial ceil-

ing can be created from a rigid sheet of polystyrene. Another option is to move the external flash away from the camera body by using a cord, then flash the light on the subject from an appropriate distance to fill in the shadows.

Standardized Extraoral Photography

For a complete photographic record, the four recommended extraoral views are full face, full face smiling broadly, right profile (and left profile in cases of facial asymmetry), and three-quarter profile (Fig. 6).[14] A submental view can be taken when necessary, as with cleft-palate patients. A three-quarter smiling photograph is another optional view. Facial photographs should be taken with the digital camera in portrait mode.

Ideally, the only variable among a series of photographs taken to show changes over time should be the patient. Everything else should stay the same: viewpoint, positioning, lighting, color, magnification, perspective, contrast, and background. The best way to standardize scale is to use a lens that is marked with reproduction ratios on the barrel. The lens is set to a constant magnification ratio, and focusing is done by moving the entire camera forward and back. Some lenses, such as the Nikon* Micro-Nikkor, are factory-marked for 35mm cameras; for digital photography with shorter focal lengths, you must either use the standardized distances or determine the desired ratios by photographing a ruler, then marking the lens barrel with tape or thin paint lines. With simpler cameras, standardization can still be achieved by maintaining a fixed distance of the tripod from the patient. If the camera has a zoom lens, it is better to alter the subject's size by changing the camera distance rather than by zooming, which changes the focal distance and thus affects the angle of view and the depth of field. Some experimentation will probably be necessary.

Positioning the Patient

Frontal view: Symmetry in the frontal view can be quickly evaluated by checking for equal visibility of the ears on both sides. In an adult patient, the photographic frame should encompass the crown of the head and the clavicle.[15] For treatment documentation over a period of years during growth and development, it is better to establish a constant distance at one-eighth magnification and not rely on the encompassing view alone.[16]

The interpupillary line should be parallel to the horizontal plane. The distance from the outer canthus of the eye to the hairline should be the same on both sides. The line from the outer canthus of the eye to the superior attachment of the ear (C-SA) should also be parallel to the horizontal plane. This line, which parallels Frankfort horizontal, is a consistent and practical reference for clinical use. Both lines are used to establish consistent parallelism between the eyes and the horizontal plane and to prevent tilting of the head in frontal and lateral views. Another method for head orientation, introduced by Broca in 1862, is "natural head position",[17] which he defined as follows: "When a man is standing and when his visual axis is horizontal, he (his head) is in the natural position." This has been shown to be a reproducible position,[17] easily obtained by having the patient look into his or her eyes in a mirror, but it does not establish references with respect to the camera, nor does it easily permit photographing the patient in a dental chair or in other non-standing positions.

Profile view: The patient's nose should be a short distance from the edge of the frame; the back of the head is not essential. Always ask the patient to pull his or her hair back behind the ears so the Frankfort horizontal view can be seen. It is also important to capture the cervicomental angle, since this will be influenced by any change in position of the mandible, whether through surgery or functional-appliance treatment. As with the frontal view, the photographic frame should encompass crown to clavicle, and the C-SA line should be parallel to the horizontal plane.

For a true lateral profile, a consistent eye-to-nose relationship is established by making certain that the inner and outer aspects of one eye are visible, that the structures of the other eye are hid-

*Registered trademark of Nikon Corporation, Tokyo, Japan; www.nikon.com.

Fig. 7 Complete intraoral photography series.

den, and that the nose appears to be more distant than and anterior to the eye. Some dental photographers recommend that the patient's face be rotated 3-5° toward the camera lens, revealing the edge of the eyebrow on the other side. This position compensates for the illusion in a straight profile that the head is turned away from the lens.

Three-quarter view: The patient's body is at a right angle to the camera, as in the profile shot, but the patient turns the head about 45° until the opposite eyebrow can be seen. Some authors suggest telling the patient to look toward the camera while keeping the head in position just as the shot is being taken.[14,15]

Head position can be standardized with a cephalostat or by verbally orienting the patient. Inconsistent head positioning creates distortion—for example, a backward head tilt gives a prognathic appearance, particularly in the profile view, and a forward head tilt gives a retrognathic appearance. Rotation of the head will affect the evaluation of symmetry in frontal views.[16]

Positioning the Camera

The distance from camera to subject will be determined by the focal length of the lens. A wide-angle lens requires a close subject to fill the field and can result in "barrel distortion", involving enlargement of the chin and nose, elongation in the anteroposterior dimension, and excessive curvature on the sides. An extremely powerful telephoto lens creates "compression distortion", with nearer subjects appearing smaller, shortening in the anteroposterior dimension, and excessive flattening of features. The best way to standardize facial portraits is to keep the focal length of the lens the same (ideally 100mm or 105mm) and maintain consistent subject-to-camera distances. Ideally, the camera can be mounted on a tripod and the same distance used each time a patient is photographed.

The ideal camera position is one in which a line from the middle of the lens to the eye is parallel to the horizontal plane. If the camera is too high, the head will appear to have a forward tilt; if the camera is too low, the head will seem to tilt backward. Centering the lens between both eyes will result in equal spacing between the hairline and the outer canthus of the eye on both sides.[16] Focus on the patient's lower eyelid to ensure that the area from the tip of the nose to the ear falls within the depth of field in the frontal, profile, and three-quarter views.[18]

Fig. 8 Supplementary intraoral photograph documenting etiology of Class II, division 2 malocclusion.

Standardized Intraoral Photography

The most common intraoral views are the frontal, right and left lateral, and maxillary and mandibular occlusal (Fig. 7). Photographs should also be taken of any clinical situation that may be of concern, including gingival recession, ankyloglossia, and hypoplastic defects. In Class II, division 2 cases, excessive coverage of the upper teeth by the lower lip can be documented by retracting the upper lip (Fig. 8).

Intraoral photographs should be kept clear of any distracting elements such as saliva or fingers; even retractors should be avoided if possible, but not at the cost of losing information. Keep the camera at the height of the occlusal plane to avoid incorrect angulation. Shooting from below can reduce the apparent depth of the bite (Fig. 9), while shooting from above eye level can give a false impression of deep bite.

Positioning the Patient

Frontal view: Retract the lips so the basal bone is visible and the roots can be assessed. The retractors should always be held so that the soft tissues do not cover the teeth; for the frontal view, the retractors are pulled laterally and outward. It is better to train the patient or an assistant to hold the retractors, so that the photographer can concentrate on stabilizing the camera.

Lateral view: The patient should be asked to turn his or her head to the side away from the buccal segment being shot, and the photographer should stand just in front of that segment. Sufficient cheek retraction is important, because a lateral view taken from a slight front angulation can make a full-cusp Class II molar relationship look end-on (Fig. 10). Retractors used for bonding, which are joined in the middle, will not provide adequate retraction for lateral photographs. If it is difficult to retract the cheek enough for a full view of the buccal occlusion, a buccal-view mirror should be used. Even with a mirror, it is not always possible to capture the second molar, but that should be the goal, keeping in mind the comfort of the patient. Glass mirrors produce a far superior photograph compared to polished metal mirrors, because they provide much greater light reflection and are more resistant to scratching.

Occlusal view: A front-silvered glass mirror can be used, and the patient should be asked to open the jaw as far as possible so the most posterior tooth can be captured. Back-silvered mirrors, though inexpensive, can produce double images

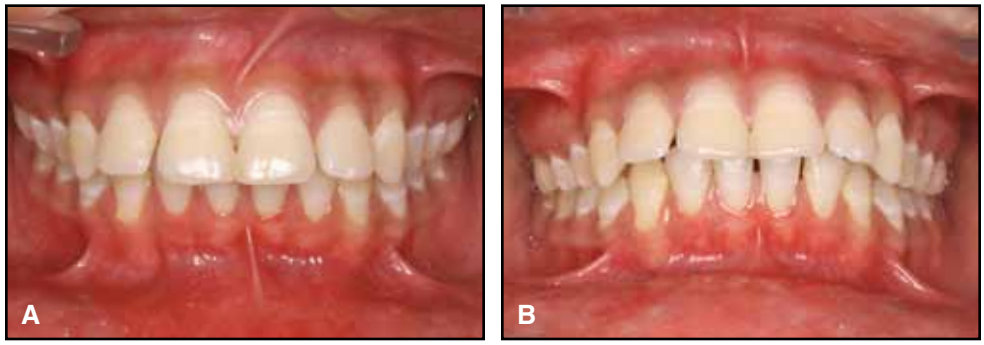

Fig. 9 A. Actual overbite. B. Apparent reduction in bite depth due to shooting from below occlusal plane.

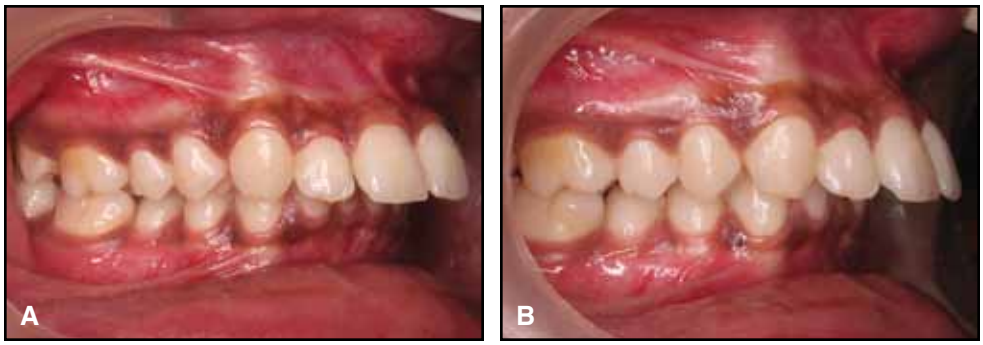

Fig. 10 Lateral view taken from slight front angulation gives appearance of end-on molar relationship (A), as compared to view from side (B).

(Fig. 4). Reclining the chair a little helps in taking occlusal shots. To prevent fogging, the patient can be asked to stop breathing from the mouth for a few seconds while the shot is being taken (not advisable with cleft-palate patients). Another way to avoid fogging is to prewarm the mirror.

Camera Settings

When taking photographs with a mirror, change the aperture compensation setting on the camera to +1 to allow more light through the lens. Although the difference between 0 and +1 settings is small, a slight underexposure of the shot will result if a mirror is used with no compensation.

For a frontal view, focus the camera on the distal surface of the lateral incisor; for a lateral view, focus on the premolars. If the flash is mounted on one side of the camera, the camera should be turned upside down to avoid shadows in the lateral view. Alternatively, a ring flash or more powerful flash can be used with TTL metering.

Conclusion

Clinical photography has been greatly improved with the advent of digital cameras, especially digital SLRs. To obtain high-quality, consistent photographs, the orthodontist must select an SLR camera that meets clinical requirements, then adjust the camera's settings according to office lighting conditions. The importance of training assistants to properly operate the camera, instruct patients during photo sessions, and manipulate retractors and mirrors cannot be overstated.

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