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FEATURES SECTION

How to avoid common errors in clinical photography

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This paper demonstrates some of the errors commonly seen in both conventional and digital photography when used for clinical purposes, and details how some of these mistakes may be avoided.

Key words: Clinical photography, digital photography, errors

Introduction

Clinical photographs taken before, during and after orthodontic treatment form an essential part of the patients' records. If correctly taken, they offer more useful information about the malocclusion and treatment than any other clinical record. There are, however, many potential sources of errors whilst obtaining these invaluable records. Photographs of inadequate quality may misrepresent the patients starting malocclusion, may inaccurately reflect progress with treatment or may inaccurately record dental anomalies and defects that may be present.

With both conventional and digital systems, many of these errors, which involve use of mirrors and retractors and patient positioning issues, are common to both methods. With the recent widespread use of digital equipment a whole new range of possible errors has been introduced and specific problems related to the digital system are discussed in detail.

The aim of this paper is to highlight the most common problems encountered whilst taking clinical photographs, and also to advise on how to minimize these errors to achieve the highest possible quality of photographic records.

Sources of errors in clinical photography

There are a number of errors that are commonly seen and these can be divided into two groups. The first group comprises errors due to inappropriate choice or use of equipment including the camera, lens, flash, retractors, mirrors or suction, or a lack of understanding of the digital technology resulting in inadequate or inappropriate images. The second group of errors relates to any recording medium and involves inappropriate positioning of the subjects.

Technical errors

Camera. The correct equipment is required for high quality clinical photographs, which include a camera (either conventional or digital) with a macro-facility (ability to produce 1 : 1 images) and, ideally, a ring flash, an appropriate background, suitable lighting and well-trained assistants. Correct camera orientation is important, with extra-oral photographs taken in portrait mode and intra-oral photographs taken in landscape mode. To allow direct comparison of photographs taken at different times consistent magnification of images is required. To aid this with conventional equipment a label can be placed on the barrel of the lens indicating the required lens setting (focal length) for each of the standard views (Figure 1). The magnification will therefore be preset for intra-oral, mirror and extra-oral views allowing direct comparison of sequential shots. The lens barrel is set to the predetermined position and the subject brought into focus by moving the camera closer to or further from the patient. With digital images this is not such a critical issue as they can be resized at a later stage to allow comparison with previous or subsequent images providing there is sufficient information on the image to guarantee quality, once

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Figure 1 Fixing the focal distance ensures consistent magnification

cropped and resized. This is determined by the number of picture elements (pixels) on the charge-coupled device within the digital camera and whether the area of interest completely fills the recorded area. Most modern digital cameras record 3 mega pixels or more, which is more than adequate for high quality clinical photography.

Retractors. Two sizes of double-ended retractor are prerequisite to obtaining a set of high quality intra-oral photographs (Figure 2). The large ends of the larger retractor are used to obtain retraction for the anterior intra-oral shot. The assistant should hold both retractors pulling them both laterally and also forwards, which is the opposite to the natural instincts of the assistants when retracting. By pulling the lips forwards towards the photographer it makes it easier for the patient to bite together in occlusion and pulls the soft tissues away from the teeth (Figure 3).

For the buccal shots, one retractor is turned through 180°, thus using the smaller end of the larger retractor on the side of interest. The photographer should hold this retractor themselves and, immediately before capturing the image, pull it an extra 4–5 mm both distally and away from the teeth to ensure at least the distal of the first molars is captured. To allow optimal soft tissue retraction the assistant passively holds the large end of the large retractor on the opposite side (Figure 4).

For both occlusal shots the assistant inserts the small ends of the small retractors under the respective lips and rotates them towards the midline pulling the lips forward, as well as laterally. This is essential to prevent obscuring the teeth with the lips. The direction of pull is away from the teeth, and upwards for maxillary shots and downwards for mandibular shots, thus ensuring a

Figure 2 The four sizes of retractors required

Figure 3 Retractors pulled laterally and towards the photographer

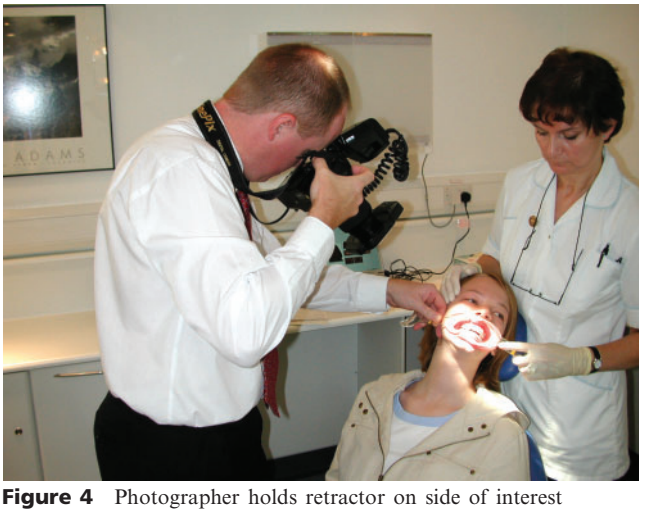


Figure 4 Photographer holds retractor on side of interest

Figure 5 Assistant pulls up, laterally and towards the photographer

background of reflected mucosa rather than stretched vermillion (Figure 5).

Mirrors. Long-handled, front-silvered, glass mirrors are the ideal tool for clinical photography, although they are significantly more expensive than rear-silvered or metal mirrors. Long handles are held by the photographer to allow complete control of the picture and to keeps assistants fingers out of the shot (Figure 5). Glass mirrors produce a far superior photograph compared to polished metal mirrors as there is much greater reflection of the light and they are more resistant to scratching. Silvering on the front side of the mirror prevents double images, which occur due to a second reflection from the glass surface when the silvering is on the back surface (Figure 6a,b).

Prior to taking the photograph the mirror should either be warmed to prevent misting of the mirror when it is inserted into the patients' mouth or the patient should be instructed to hold their breath for 10 seconds or so.

The occlusal mirrors are available in three different sizes; however, the two smallest sizes are required in less than 10% of patients (Figure 7). During occlusal photography light is never reflected 100%, and there is a tendency for mirror photographs to be slightly under-exposed (Figure 8). It is therefore worth using an aperture compensation of +1 F-stop, to ensure good illumination of mirror shots. This adjustment can be usually made on both conventional and modern digital camera systems.

Problems related to digital photography

- Depth of field*.
- Auto focus*.

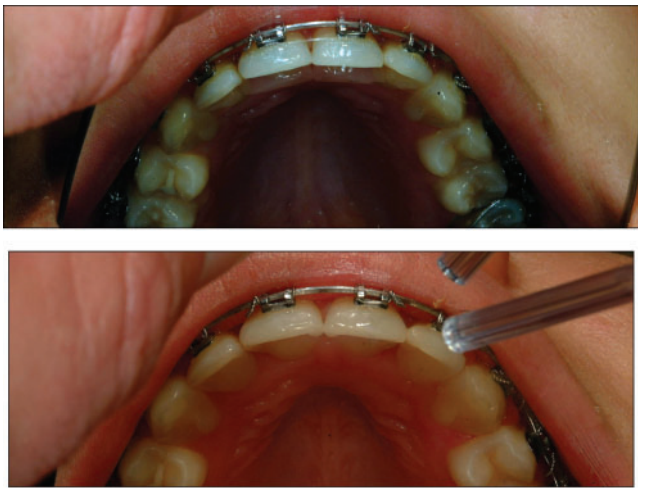


Figure 6 (Top) Ghost image from glass and image from rear silver. (Bottom) Sharp image when front silvered surface used

- Shadows*.
- Constructing symmetrical images.
- Image storage.
- Digital image—fit for purpose?

*Problems frequently encountered when using mid-range 'Prosumer' cameras.

Depth of field problems. The depth of field represents the amount of the image that is in sharp focus, and is dependant upon magnification and the aperture selected. As the magnification increases and as the aperture through which the picture is taken widens the depth of field reduces. Many mid-range digital cameras that bridge the gap between consumer and professional

Figure 7 Long-handled mirrors are the best available

Figure 8 Light never reflected 100%; therefore, aperture compensation required

Figure 9 Focus lost distal to canines

models, (known as 'Prosumer' cameras, e.g. Nikon Cool Pix 990/4500) will only allow the aperture to be reduced to about F11. When taking intra-oral photographs with these mid-range cameras the depth of field will be relatively small and on the anterior intra-oral photograph part of the picture will inevitably be out of focus (Figure 9). The depth of field is distributed approximately one-third in front and two-thirds behind the focal plane (Figure 10). This disadvantage of small depth of field with pictures taken with larger apertures can be minimized (but not avoided completely) by focusing on the distal surface of the lateral incisors to at least get central incisors to canines in focus.

With professional digital cameras, e.g. Fuji S1 FinePix Pro, combined with the powerful Nikon SB29 flash, which allows through the lens metering a perfect exposure is possible on F32. This tiny aperture allows sufficient depth of field to include both incisor brackets and second premolar brackets in sharp focus provided the focal plane is positioned correctly, i.e. on the mesial of the canines (Figure 11). With buccal shots and occlusal shots, provided the subject is correctly positioned and retractors are appropriately used, all the area of interest is on one plane; therefore, depth of field should not be an issue.

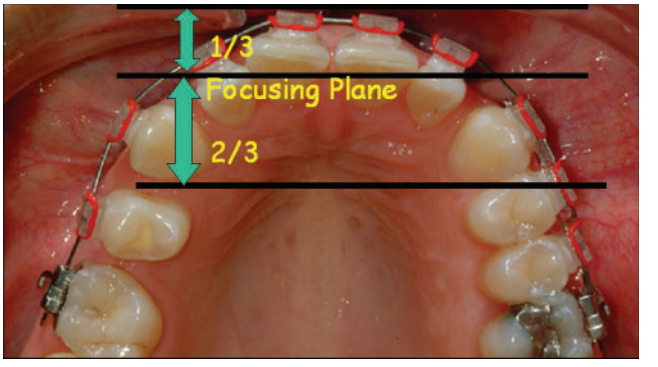


Figure 10 Depth of field one-third in front and two-thirds behind focusing plane

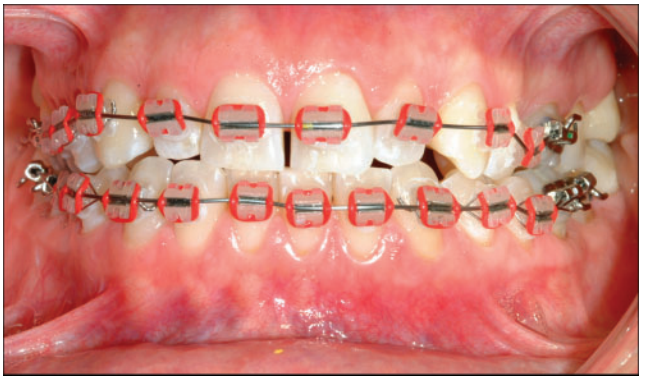


Figure 11 Small aperture (F32) allows central incisors to molar tubes in focus

Auto-focus problems. Digital cameras often allow the choice between auto-focus or manual focus. Manual focus is by far the preferred option for the following reasons. With Prosumer cameras focusing has to be on the lateral incisors and with top end cameras on the canines, whilst still maintaining a centred photograph. Because of the lack of sharply contrasting lines in the area of interest many of these digital cameras have difficulty focusing using the auto-focus setting for intra-oral photographs. The result of this is attempt after attempt to get the camera focus light (usually flashing green) to stop flashing, indicating that the shot is in focus. This often proves fruitless despite repeatedly

Figure 12 Frustrating attempts to get auto-focus to work

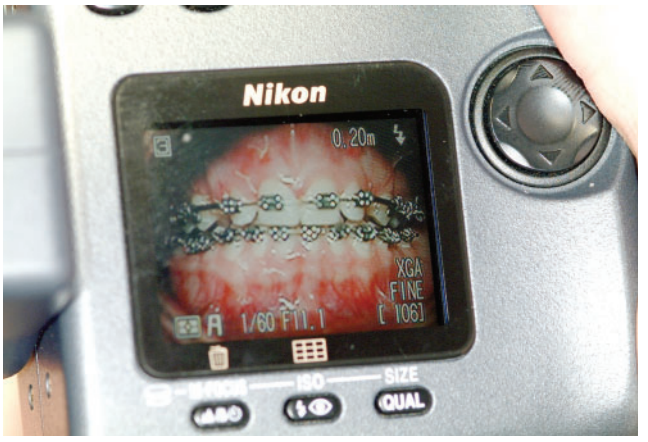


Figure 13 Focal length set at 0.2 m (top right), camera moved until image sharp

moving the camera slightly between attempts at focusing. All this is occurring whilst the assistant and the clinician are heaving on the retractors to get maximum retraction of the soft tissues and some patients may find this a little uncomfortable (Figure 12).

The solution to this problem is to use the manual focus setting for all clinical photography. With top end cameras with through the lens (TTL) facility focusing is done looking through the viewfinder. With the Prosumer models, the clinician decides the appropriate distance between the patient and the camera that fills the frame with the area of interest, This focusing distance of, for example, 0.2 m, is set manually on the camera, and the camera is then merely moved backwards and forwards until the image on the LCD screen is in sharp focus, and the picture is taken. Twenty centimetres is a good distance to start testing the cameras ability to take sharp anterior intra-oral photographs on manual setting (Figure 13).

For extra-oral photography an attempt should be made to focus on the patients lower eyelid to ensure from the tip of the nose to the ear of the patient falls within the depth of field on the front, three-quarter and profile views (Figure 14). Using the dental light to illuminate the patient not only helps to reduce red-eye, but also greatly aids focusing in poorly lit surgeries.

Shadow. Problems involving shadowing are almost inevitable with Prosumer digital cameras that use a point flash. If the flash is mounted to one side of the lens this shadowing is particularly noticeable on the lateral shot and on the anterior shot if the flash is above the lens (Figure 15a,b). Various mirrors, reflectors and diffusers have been suggested in the past to reduce this problem; however, none provide the perfect solution and the additions tend to make the set-up unwieldy to use.

The other alternatives are either to use an illuminated screen as the backdrop to the patients when taking the extra-oral photographs, or use a dark non-reflective background (preferably velvet) to maximize the quality of the image.

With intra-oral views again the solution with a side mounted point flash is to turn the camera upside down on the buccal view with the very dark buccal corridor (Figure 17). This will ensure the flash illuminates the area that would otherwise be in shadow due to the cheek (Figure 18). This digital photograph can then be rotated 180° before the picture is saved in the patients file.

High quality occlusal photographs are also difficult to obtain using cameras with point flashes with the usual magnification, because of the proximity of the camera to the patient, much of the area of interest is in shadow (Figure 19a). One solution to the problem of inadequate illumination is to focus further away from the patient,

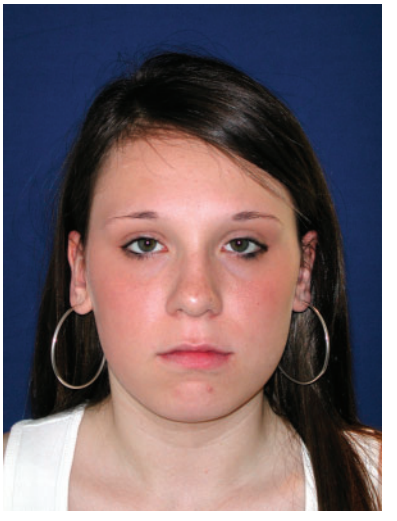
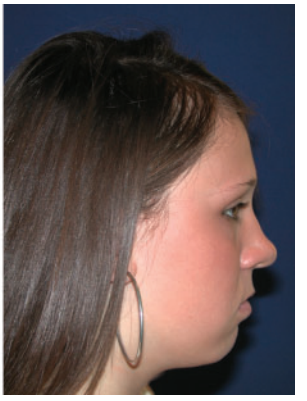


Figure 14 Focus on lower eyelid whilst keeping subject centred

(a)



(b)

Figure 15 (a,b) (left and middle) Shadow thrown in front of or below subject because of flash position problems of shadowing on extra-oral lateral shots can also be overcome by either switching off the part of the ring flash, which throws the shadow in front of the subject if this is an option, or rotating the camera through 180° to ensure the flash throws the shadow behind the patients outline (Figure 16)

Figure 16 (right) Adjustment of flash or camera position to throw shadow behind subject

which allows more light in and therefore reduces shadowing. In this situation, the area of interest only fills about 20% of the area captured by the camera so the charge couple device must be of high enough quality to produce a good image after 80% of the information captured has been discarded (Figure 19b).

Constructing symmetrical images. One major advantage of the very popular Dental Eye 3 camera, over many of its competitors, was the presence of a graticule in the viewfinder. This allowed very well constructed symmetrical and balanced intra- and extra-oral photographs to be taken, even by relatively inexperienced photographers using the occlusal plane the interpupillary line and the Frankfort plane to construct reproducible photographs. Most of the mid-range digital cameras do not have the benefit of a graticule to help with construction of the photographs, but some of the top end cameras, e.g. the Fuji FinePix S2 Pro, have 'on-demand' grid lines, which help significantly with construction of the extra-oral and intra-oral images.

Card problems. The digital images are often recorded onto PCMCIA cards. These cards have a series of 50 small holes that accept 50 tiny metal pins within the camera. Small imperfections in the PCMCIA card (Figure 20) may damage the pins (Figure 21) and once damaged will necessitate return of the camera to the manufacturers for repair.

CCD problems. Even when the lenses on the digital cameras are never changed dust may still eventually get

Figure 17 Dark right buccal corridor as cheek prevents light from left mounted flash

Figure 18 Shadow overcome by turning camera through 180° so the flash is now on left

(a)

(b)

Figure 19 (a) Occlusal shots poor if point flashes as insufficient light illuminates subject. b) Focusing much further out will allow more light in, requiring quality CCD

onto the CCD of the cameras. This will be seen as tiny 'in focus' black marks, at a specific spot on intra- and extra-oral images (Figure 22). On SLR type cameras it is often possible to get access to the CCD to allow it to be cleaned with optic cleaning liquid on lint-free non-abrasive cloths, but this must be done with extreme care. If in any doubt at all the camera should be returned to the manufacturer for this to be carried out.

Digital image: fit for purpose? Most digital cameras come with a variety of settings and it is sometimes difficult to know which is the best setting to use in any particular situation. The questions that need to be answered are what will the digital image be used for, is memory card space at a premium and will the images ever be used to produce hard copy?

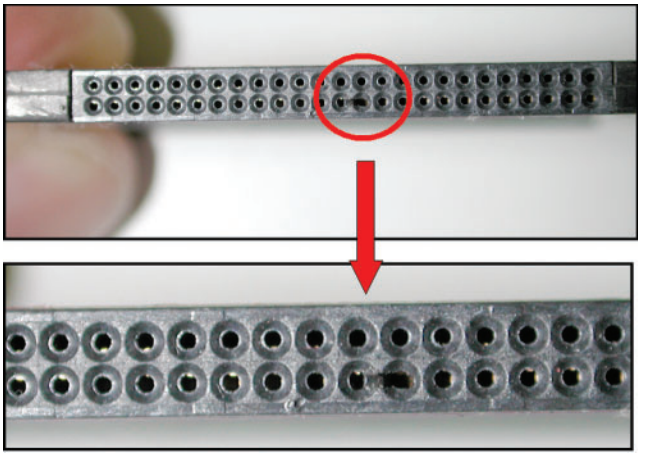


Figure 20 Defect in 2 lower central holes on PCMCIA card

When deciding upon the type of image there are choices about the pixel dimensions. These may be 3040, 2048, or 1024 pixels across the wider dimension of the image. (Cheaper cameras have even smaller dimensions of images, but the quality of these is usually unacceptable for clinical purposes). If the image is only ever to be viewed on a computer screen, there is little point having more information available than can be exhibited on the screen, or displayed using a laptop projector. The average screen has 1024 pixels across, so if a landscape image is going to occupy the whole screen 1000 pixels across will be the setting of choice, reduced proportionally as the area of the slide occupied by the image is reduced (Figure 23).

Keeping images as small as possible will ensure that the slideshows into which they are imported are a manageable size, and that the computers do not struggle when displaying the slideshow. When creating an orthodontic slideshow an image will often only occupy half of the screen so the image size can be reduced further, to 500 pixels on its horizontal axis, using any of

Figure 21 Damaged card bends the pins inside the camera

Figure 22 Hairs and dust eventually get onto the CCD

the commonly available image manipulation programmes, prior to insertion into the slide show. This is preferable to grabbing the corners of a grossly oversized image and 'squashing' it to within the dimensions of a Powerpoint slide, as all the superfluous 'memory hungry' information is still within the file making the slideshow unnecessarily large and often unwieldly.

On most digital cameras there is also a setting for image quality, as various degrees of compression are used to reduce memory requirements. A common situation is for the camera to save files at maximum quality with no compression as TIFF files and to have 2 or 3 levels of JPEG compression represented by the 'fine', 'normal' and 'basic' settings. Roughly, the file sizes are reduced to 1/4, 1/8 and 1/16 of the original file size by successive compressions. The 'normal' setting produces images that are adequate for most purposes, and the 'High', and 'Fine' settings are generally required when hard copy prints are required.

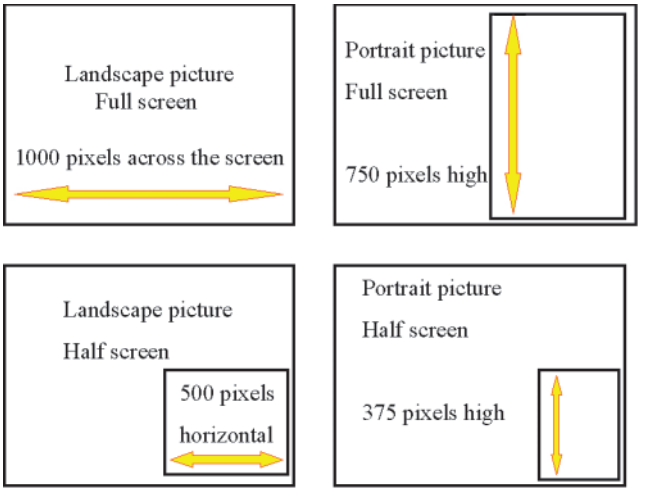


Figure 23 Images should be as small as possible to maintain quality

(a) (b)

Figure 24 (a,b) Height adjustments for photographer and the patients should be possible

If there is a possibility that the digital image will need to be printed at some stage then for photographic quality printing a resolution of approximately 300 pixels per inch is required. For a good quality 6×4 inch print the image needs to be taken with the 2048 pixel setting across its longer dimension. Images taken for publication purposes, therefore, need to be of a higher size and ideally higher quality (less compression) than those taken for routine patient records.

The typical setting for standard digital photographs using a Fuji FinePix S2 Pro is the 1440 setting on 'normal' for the intra-oral photographs and using a $+1$ compensation for mirror shots. The aperture of the camera is set at F32 for both types of intra-oral photographs and F5.6 for extra-oral photographs.

Positioning errors

Both the patient and the clinician need to be positioned correctly, in a standardized manner, to produce consistent photographs. All features of the malocclusion should be demonstrated, and areas of interest not obscured by clothing, hair, impression material, retractors or saliva.

Problems may be encountered where there is a height difference between the patient and the clinician, and it may not be possible to get a uniform background as the photographs may appear to be taken above or below the patient. This problem can be solved by getting the patient or the clinician, which ever is appropriate, to stand on a platform to raise them to the same height (Figure 24a,b).

The required photographs and the objectives for each shot have been previously outlined.[1] Extra-oral photographs

Figure 25 (Left) Light box behind the patient eliminates shadows completely
Figure 26 (middle) 'Noise' in the background detracts from the photograph
Figure 27 (right) Instructions taken too literally

include a full face view, a full face smiling view, a profile view and a three-quarter profile view, and the intra-oral photographs include an anterior view, and right and left buccal views of the teeth in occlusion, and upper and lower occlusal views.

With all cameras time must be spent calibrating the system to determine the optimal settings for both intra- and extra-oral photographs. Intra-oral photographs should be taken with the smallest aperture possible to maximize the depth of field.

Extra-oral photographs

Full face and full face smiling views

Ideally, this is a 'portrait' view with the face filling the frame extending to just above the top of the head and just below the chin. The photograph should be symmetrical with the interpupillary plane parallel to the floor. If possible, the dental light is directed towards the patient to constrict their pupils to minimize any 'red eye' effect.

The first photograph is taken with the lips at rest and the next one with the patient grinning broadly showing their teeth. Commonly seen features of a poor extra-oral shot include the photograph taken in landscape orientation, at the wrong magnification and too much of the patient's torso in the photograph.

An appropriate and consistent background should be selected, such as a blue non-reflective material, or alternatively to eliminate shadows completely a light box (Figure 25). Soap containers, light switches, door handles and edges of notice boards add 'noise' to the view and detract from the overall quality of the final picture (Figure 26).

It is important to give clear and concise instructions to the patient. Occasionally, when asked to stand in front of the background, patients will take the instructions too literally and turn their back to the photographer (Figure 27), highlighting the need for explicit patient instructions.

Profile and three-quarter profile views

Usually only one profile (the patients right profile to match up with the lateral cephalogram and tracing) is taken. However, for patients with facial asymmetries both right and left profiles should be taken. Again, the face should fill the frame extending to above the top of the head, in front of the nose and below the chin. The back of the head is not necessarily required and it reduces the size of the frame occupied by areas of interest. The patient's Frankfort plane should be horizontal. The dental light, if required, should be directed so that the patient's shadow is thrown behind the patient and the camera's flash, where possible, should be adjusted for similar effect.

Errors with profile shots include a misrepresentation of the soft tissue morphology or skeletal pattern and this may be due to patient posturing or alternatively excessive tilting of the head forwards or backwards (Figure 28a–f). Subjects with long hair should always be asked to tuck it behind their ears so that the Frankfort plane may be assessed accurately (Figure 29a,b) and the area of interest is fully exposed.

(a) (b) (c) (d)

(e) (f)

Figure 28 (a) Class 3. (b) Class 1. (c) Class 2. (d–f) Differing skeletal pattern purely due to patient positioning errors

Intra-oral photographs

Anterior views

This is taken in 'landscape' view, with the teeth in occlusion filling the frame, with the occlusal plane horizontal and bisecting the picture. Once the correct retractors have been selected all soft tissues should be retracted away from the teeth laterally and anteriorly. The midlines, if they are correct, should be in the centre of the frame. One possible error, although relatively uncommon, is taking an intra-oral shot in portrait orientation.

Common errors include canted occlusal planes, inappropriate selection and use of cheek retractors. Another totally preventable error is saliva not aspirated or the tongue not retracted before the photograph is taken, and bits of alginate left on the teeth.[1] It is therefore worth familiarizing the assistants with the retractors, always having good suction available and taking photos before impressions when collecting records.

To aid focusing for intra-oral photographs the dental light should always be shone directly into the patients' mouth. Adequate depth of field is required particularly for the anterior photograph, so it is important to focus on the level on the lateral incisors to ensure that the maximum number of teeth are in focus.

(a) (b)

Figure 29 (a,b) Patients hair should be brushed back to reveal area of interest

Buccal views

Again the occlusal plane should be horizontal and bisect the frame. The frame should be filled with teeth

extending from the mesial surface of the central incisor to at least the distal surface of the first permanent molars and further posteriorly if possible. It is important to angle the camera so that the lens is perpendicular to a tangent to the buccal surfaces of the posterior teeth to avoid underestimation of the sagittal discrepancy, which occurs through a 'parallax' effect (Figures 30 and 31).

Mirror views

The upper and lower mirror shots should ideally be symmetrical views of the occlusal surfaces of the teeth, extending from just in front of the incisors to at least the distal surfaces of the first molars and ideally to include all the erupted teeth. There should be no direct view of the incisor teeth.

Whilst setting up for the mirror shots move the patient by tilting their head back so that the photographer doesn't have to stoop or twist excessively. There is always a tendency for patients not to open their mouth fully for these occlusal shots. To avoid this problem, after placing the mirror and just prior to talking the shot ask the patient to open 'twice as wide', which usually provides significantly better opening for the shot. Remember that whatever is seen through the viewfinder is invariably what will reproduced on the final photograph. Photographs taken with a mirror require the aperture compensation setting on the camera to be changed to +1 to allow more light in. The differences between 0 setting and +1 are small, but demonstrate slight underexposure of the shot when mirrors are used with no compensation (Figure 32a,b).

With conventional slide photography never trust the last slide (Figure 33) on the film as, during processing, the ends of the films are joined together and this may

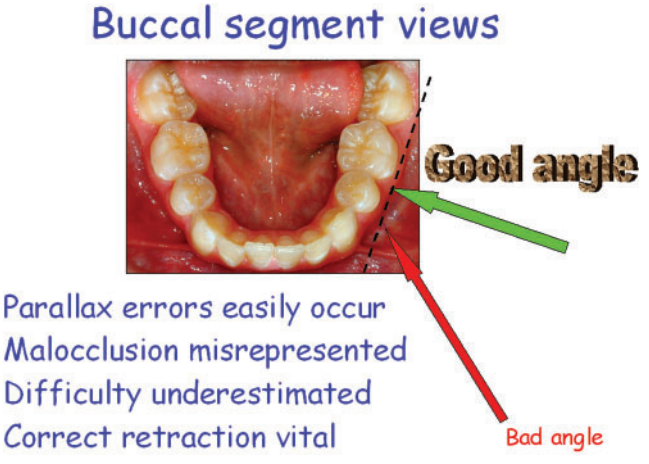


Figure 30 True representation of the malocclusion depends upon correct camera positioning

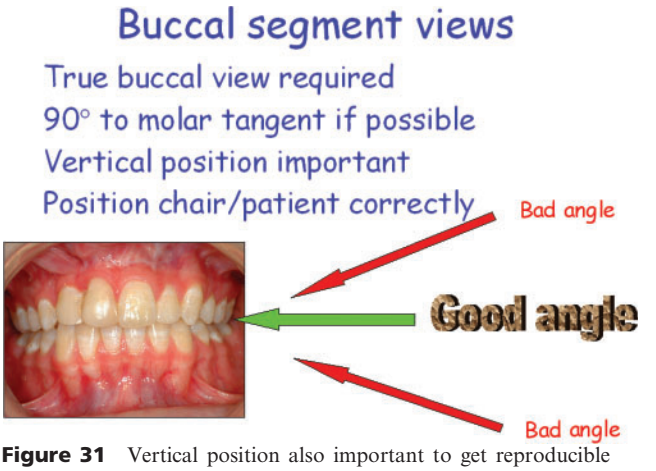


Figure 31 Vertical position also important to get reproducible and representative photographs

(a)

(b)

Figure 32 (a,b) The effect aperture compensation for mirror shots

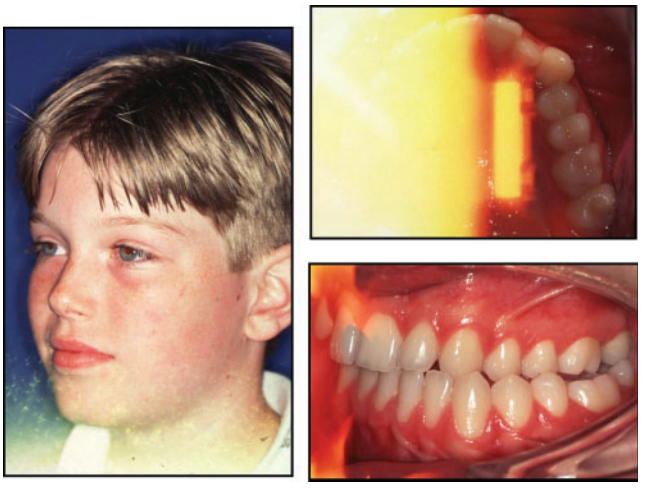


Figure 33 Never try for 'just one more' photo once the exposure number has been reached

result in exposure to light thus spoiling the last frame. Therefore, always settle for 36 shots per film and rewind at that stage, rather than attempting to squeeze another 1 or 2 prints on the film.

Many of the aforementioned errors can be overcome with meticulous attention to technique and the use of digital photography. Positioning errors and camera errors are noticed immediately on the LCD screen, which is a major advantage of digital photography. Other errors can sometimes be compensated for by image manipulation at a later date,[2] but this is not without its disadvantages. Rotation of images for example will lead to distortion of straight lines and thus 'steps' in archwires.

Resizing digital images is of course possible, but information is unnecessarily sacrificed if the frame area is 'wasted' by filling it with areas of no interest. Some programmes such as Dolphin™ allow guide lines to be used when resizing images so consistent magnification is almost guaranteed. The principles of use of retractors, mirrors and suction are identical whether using conventional or digital equipment.

Conclusions

Good quality accurate clinical photographs can easily be obtained using the correct equipment and appropriately trained staff. An awareness of all the possible errors in extra- and intra-oral clinical photography will increase the chances of obtaining high quality images.

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