



A Short Guide to
Clinical Digital Photography
in Orthodontics



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Shadi Samawi BDS, MMedSci, MOrthRCS

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Layout, Cover & Back-Cover Design
Shadi Samawi

Cover & Back-Cover Photographs
www.deviantart.com

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1. Introduction

Why Take Orthodontic Photographic Records?

The basic Orthodontic Record-taking is comprised of three main types of records:

1. **Study models**; properly-trimmed, dental stone-cast moulds.
2. **Radiographs**; usually a Panoramic view (OPG) and a Lateral Cephalometric view.
3. **Clinical photographs**.

Each of these types of records provides certain diagnostic information to the orthodontist to aid him/her in diagnosing and determining the best possible treatment plan for each particular case. The emphasis has long been on taking the first two (study models and X-rays), while the third (clinical photographs) was often seen as a luxury; an unnecessary waste of the clinician's time, by many orthodontists!



The Benefits of taking Clinical Photographs

Times have certainly changed. Now, with more and more emphasis from the orthodontic community on the achievement of balanced facial harmony and smile esthetics for our patients, in addition to the traditional orthodontic goals of a well-aligned and functional dentition, the need for proper clinical photographic records of the orthodontic patient has become more obvious and essential for proper treatment-planning and follow-up.

Clinical photographs allow the orthodontist to carefully study the existing patient's soft-tissue patterns during the treatment planning stage. We can assess lip morphology and tonicity, the smile arc and smile esthetics from various angles. We can also assess the degree of incisal show upon smiling. Thus, they allow us to study the patient in a so called “social” setting, and all that without the patient ever being present. Such information greatly aids the orthodontist in formulating the best possible treatment plan for each patient, and for monitoring in subsequent follow-ups.

Obviously, there has always been the need for photographic records for purposes of research and publication, and for lecturing and teaching presentations. Also, the growing importance of the need for such records for medico-legal reasons cannot be over-emphasized.



Why Go DIGITAL?

Going for a digital camera is THE obvious choice in this digital age. One of the major reasons is the ease of use of such cameras, along with the ability to repeat / delete unsuitable images on the spot. There is no need to wait till the film is developed to check your photos. Any problems can be easily rectified immediately. Another important advantage is the “Running Cost” issue. Digital camera setups are cost-effective; no more buying film, no more developing costs and hassles, and no more worries about where to store all the slides and “physical” photographs of your patients. All you need is a one-time investment in a suitable digital camera setup, a generous memory card, and a reasonable-size computer and hard disk.

The last advantage to mention is the ability to enhance, or “post-process” your images. Even if some images are still not suitably aligned, rotated, or the color, brightness or saturation etc. Is not up to standard, it is very easy to adjust those using a suitable image-editing software on your computer, before saving the images in the patients’ file.

2. Basic Terms

Resolution

Resolution describes how much detail an image can hold. An image's resolution is determined by the image's pixel count and the bit depth of each pixel. A pixel is the smallest discernible element in an image. Each pixel displays one color. A pixel's color and brightness range is determined by its bit depth. Pixels are grouped together to create the illusion of an image. As the number of pixels increases, the image's detail becomes sharper.

A camera's resolution is calculated by the number of megapixels (millions of pixels) its digital image sensor is capable of capturing. A display's resolution is expressed in pixels per inch (ppi) or as a maximum dimension, such as 1920 x 1280 pixels. A printer's maximum resolution is expressed in dots per inch (dpi)—the number of dots it can place within a square inch of paper. The number of megapixels a camera is capable of capturing can be used to roughly determine the largest high-quality print that the camera is ultimately capable of producing.

Adapted From: "Aperture: Photography Fundamentals"; Apple Inc.

Megapixels	Print dimensions at 200 dpi	Approximate uncompressed file size
1	4" x 3"	1 MB
1	4" x 3.5"	2 MB
2	6" x 4"	3 MB
2.5	10" x 6"	7 MB
4	12" x 8"	12 MB
5	14" x 9"	15 MB
7	16" x 11"	21 MB

The minimum camera resolution suitable for orthodontic purposes would be around 3-4 Megapixels. Although a higher resolution would be an added advantage, it ultimately results in larger file sizes and thus requires larger capacity hard drives for storage.

Focal Length

An important attribute of a lens, besides its quality, is its focal length. Focal length is technically defined as the distance from the part of the optical path where the light rays converge to the point where the light rays passing through the lens are focused onto the image plane—or the digital image sensor. This distance is usually measured in millimeters. From a practical point of view, focal length can be thought of as the amount of magnification of the lens. The longer the focal length, the more the lens magnifies the scene. In addition to magnification, the focal length determines the perspective and compression of the scene.



Shutter Speed

Shutter speed refers to the amount of time the shutter is open or the digital image sensor is activated. The exposure of the image is determined by the combination of shutter speed and the opening of the aperture. Shutter speeds are displayed as fractions of a second, such as 1/8 or 1/250. Shutter speed increments are similar to aperture settings, as each incremental setting either halves or doubles the time of the previous one. For example, 1/60 of a second is half as much exposure time as 1/30 of a second, but about twice as much as 1/125 of a second.

Macro Function / Lens

Macro photography refers to *close-up* photography; the classical definition that the image projected on the "film plane" (i.e film or a digital sensor) is the same size as the subject. Most Point-&-Shoot digital cameras have a built-in Macro function that is reasonable for dental photography purposes. However, a dedicated Macro lens attached to a DSLR camera provides even better close-up photos usually with higher definition and better focus.



3. Clinical Requirements For Photographic Records

Digital Camera Setup / Ring Flash / Macro Lens

There are two types of digital cameras available; the “Point & Shoot” digital camera, and the DSLR (Digital Single Lens Reflex) cameras. The DSLRs are what professional photographers currently use, as they allow maximum flexibility and customization for the highest possible quality of digital images. There are many cameras from both spectrums that are suitable for dental/orthodontic record-taking purposes, however, this section will focus on the two most important general requirements for any camera chosen; namely the ring flash, and the macro lens.

Ring Flash Vs Point Flash

The Point Flash may sometime produce fairly good light distribution when used for clinical photographs. However, frequently, distracting shadows, which may also obstruct important details do occur. These



are often irreparable using image editing software, and will detract from the final quality of the image, and possibly the information gained from it.

In contrast, the Ring Flash eliminates such shadows by allowing a more even and thorough distribution of light during extra and intra-oral photographs (See figure on left), and thus the quality of the image is enhanced.

It is highly recommended to use a Ring Flash for orthodontic photography.



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Macro Lens Vs Macro Function

Many “Point & Shoot” digital cameras have a Macro function; a function that allows for taking close-up shots of objects in good focus and depth of field. However, this is not entirely satisfactory for great and consistent results every time. A dedicated macro lens that can be attached to the camera and adjusted as needed is by far the superior choice.

Based on the previous points, DSLR Cameras are highly recommended for taking orthodontic photographic records. The high level of professional customization and wide range of possible settings allow for the best professional-looking, high-quality photos possible.

Special Cheek Retractors

The recommended cheek retractors to be used for best results in clinical photography are the **double-ended retractors** shown on the right (See image).

There are two sets of double-ended retractors; one set with a Regular and Small size either end (**Small set**). These are mainly used for intra-oral occlusal shots (mirror shots). The other set has a Narrow end and a Wide end on the other (**Large set**). These are used for intra-oral frontal and buccal shots.

Although other types of retractors are available on the market, it is accepted by most that this selection presents the most ideal set to be used for clinical photography, as they greatly facilitate taking almost any kind of intra-oral photographs with clarity and with the largest possible field of vision. Smaller one-piece orthodontic bonding retractors are generally NOT a good choice for orthodontic purposes, especially for buccal and occlusal shots, as their retraction potential is very limited, and it can often prove to be a “painful experience” for the patient.



It is recommended to buy a good quality brand of these recommended retractors to ensure durability and reliability, with recurrent disinfection procedures.

Dental Photography Mirrors

Many types of mirrors have been used for clinical photography, ranging from front-silvered mirrors to highly-polished Stainless Steel mirrors. **Front-silvered mirrors** seem to offer the best image quality and light distribution over other types of mirrors. As you can see from the accompanying figure, with front-silvered mirrors, no “ghost” image, or double-layering occurs. In contrast, with glass or rear-coated silvered mirrors, the ghost image can severely affect the quality of the image, resulting in “Haziness” or a “Double-Image”. Also, light reflection is not on par with the front-silvered mirrors, leading to a “dimmed”, darkened image as an end-result.



In addition, it is preferred to use “**long-handled**” mirrors (see Image) as they allow better control and handling by the clinician during the occlusal shots. You can find different sizes for use with different patients depending on age and mouth-opening size, but generally, the “**Medium**” sized mirrors would be fit for use with most patients.



Mirrors with no handles may be used successfully but are more tricky to handle, especially when “juggling” an “expensive” digital camera with the other hand!

4. Taking Clinical Photographs

How Many Photographs Do We Need?

Different clinicians take different numbers of clinical photographs, depending on who you talk to! There is no “standard” set that is universally-approved as a rule of thumb. However, it can generally be accepted - based on many authorities’ opinions in this field - that a complete “**Clinical Photographic Set**” for any orthodontic patient at any stage of treatment, that would enable the clinician to obtain maximum benefit and information, should include **a minimum of NINE photographs; FOUR extra-oral, and FIVE intraoral photographs.**

Extra-oral clinical photographs are the easiest photographs to take. They only require proper positioning of the patient and clinician, in addition of course to the digital camera setup itself. **Intra-oral** photos require - in addition to the camera setup - the proper cheek retractors, dental photography mirrors, as well as a well-trained assistant if possible. Clinical steps for properly taking each photograph is explained further.

Extra-oral Photographs

Extra-oral photos consist of the following four shots:

- 1. Face-Frontal (lips relaxed).**
- 2. Face-Frontal (Smiling).**
- 3. Profile (Right side preferably - Lips relaxed).**
- 4. (45 °) Profile (also known as 3/4 Profile - Smiling).**

These four shots provide the clinician with maximum possible information about the patient’s facial and soft tissue features, proportions, and Smile esthetics.

Face - Frontal (Lips Relaxed)

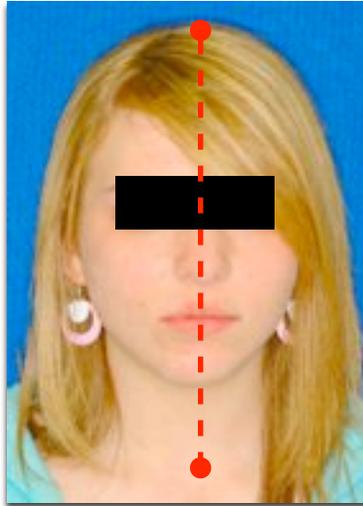


The first extra-oral photo to be usually taken, this photo is probably the easiest. However, there are still some important guidelines that need to be taken into account when taking this shot.

First, the **Framing** of the shot, should encompass the whole of the patient's face and neck, with a reasonable margin of space all around. This is ensured by holding the camera lens in a vertical position, and by standing a reasonable distance away from the patient when taking the shot. The following general guidelines should also be noted:

- A. The patient should stand with their head in the **Natural Head Position**, with eyes looking straight into the camera lens.
- B. The patient should hold their teeth and jaw in a relaxed (**Rest**) position, with the lips in contact (if possible) and in a relaxed position.
- C. Make sure patient's head is not tilted or their face rotated to either side; the shot should be taken at **90° to the facial mid-line** from the front.
- D. Ensuring the patient's **inter-pupillary line is leveled** is very important.

It is recommended that the patient stands in front of a plain, dark or white-colored wall or background when taking all extra-oral shots. This is to ensure maximum clarity of facial features and outlines without the presence of distracting objects in the background.



Face - Frontal (Smiling)



The same guidelines as for the Face - Frontal shot apply here, with the simple but important exception that the patient should be SMILING in a natural way, with the teeth visible. This photo greatly aids in visualizing the patient's Smile esthetics and soft tissue proportions during smiling.

Profile (Right Side - Lips Relaxed)

The Profile photo has a high diagnostic value to the orthodontist. After taking the frontal face photos, the patient is asked to bodily turn to their left, thus having their right profile side facing the clinician. The head should be in the Natural Head Position, with their eyes



fixed horizontally (preferably at a specific point at eye-level, or at the reflection of their own pupils in a mirror). The wrong head posture can result in confusion regarding the patient's actual skeletal pattern.

Ideally, the whole of the right side of the face should be clearly visible with no obstructions such as hair, hats or scarfs.

For the most useful, professional-looking photo possible, the use of the Ring-Flash is essential. As explained earlier, the Ring-Flash will eliminate any shadowing of the border of the patient's profile onto the background, which can compromise the quality of the photo considerably.

45° Profile (3/4 Profile) - Smiling



The final extra-oral photograph to be taken, this shot conveys the patient as if in “social interaction”, and can give valuable information about the smile esthetics' changes pre- and post-treatment.

From the Profile photo position, the patient is asked to turn their heads slightly to their right (about 3/4 of the way - hence the name), while keeping their body still in the previous “Profile Shot” position i.e. Facing forward. They are then instructed to look into the camera mostly by turning their eyes further to the right to meet the lens, and then smile. It is essential that the patient's teeth show clearly when smiling, otherwise the photograph would be of minimum benefit.

Notes on Extra-oral Photographs

- The background used in taking the photos should be either a solid-white background (or a back-lit light-box), or a solid-dark color such as Dark Blue. Taking extra-oral photos with the patient sitting on the dental chair or with multiple objects in the background should be avoided.

- The clinician's positioning for these photos would be standing a few feet away from the patient, and at the same eye level if possible. Younger and shorter patients can stand on a special stand to get them to reach a suitable height if needed.
- All extra-oral photos require that the Aperture value (F value) be set to a minimum e.g F8 is usually a suitable setting.

Intra-oral Photographs

Intra-oral photographs require more attention to detail to produce good results. For these shots, the use of the special cheek retractors and dental mirrors will be required, in addition to help from a dental assistant.

There are five required intra-oral photographs:

1. **Frontal - in occlusion**
2. **Right Buccal - in occlusion**
3. **Left Buccal - in occlusion**
4. **Upper Occlusal**
5. **Lower Occlusal**

The last two photos are also called "Mirror" shots, as they require the use of dental mirrors.

Frontal - in Occlusion

The first photo usually to be taken of the set. With the patient sitting comfortably in the dental chair and raised to *elbow-level* of the clinician, the assistant stands *behind* the patient and uses the first *larger set of retractors from the wide ends* to retract the patient's lips ***sideways and away from the***



teeth and gingivae, towards the clinician. This is important to allow maximum visualization of all teeth and alveolar ridges in the photograph, and also to minimize any discomfort for the patient from retractor edges impinging on the



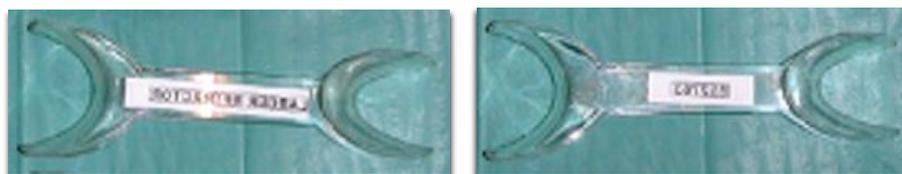
gingivae. The photo should be taken 90° to the facial mid-line using the upper frenal attachment as a guide. The dental mid-lines are not as reliable for this purpose as they can be shifted to one side or the other depending on the malocclusion present. The full extension of the sulci is paramount for full visualization and clarity, and the *high F value setting* e.g. F32 is required to attain *maximum depth of field* of the shot with even the last visible molars fully in focus. The Ring-Flash will greatly aid in producing a quality photograph by ensuring the best possible light distribution of the image without shadows, especially of the deeper parts of the oral cavity and buccal vestibules.

Right Buccal - in Occlusion

Usually the second shot in the series. The assistant flips the right retractor to the narrower side, while the left retractor remains in place as for the previous frontal shot. The patient is asked to turn their head slightly to their left so their right side will be facing the clinician. Here, the clinician holds the right



retractor and stretches it to the extent that the last present molar is visible if possible, while the assistant maintains hold of the left retractor, without undue



stretching. Again, the shot is taken 90° to the canine-premolar area for best

visualization of the buccal segment relationship, as this is very important in orthodontic assessment. A useful tip would be to for the clinician to fully stretch the right retractor *just before* taking the shot to minimize any discomfort for the patient, and achieve maximum visibility of the last molar.

Left Buccal - in Occlusion

The third shot in the series, it is very similar to the Right Buccal shot. The assistant now switches the retractors with the narrow end on the photo side (patient's left) and the wide end on the other (patient's right). Again, the shot is taken at 90° to the canine-premolar area, and to ensure this, the clinician should move their body slightly to the right while holding the retractor on the photo side, while the patient turns their head slightly to their right.

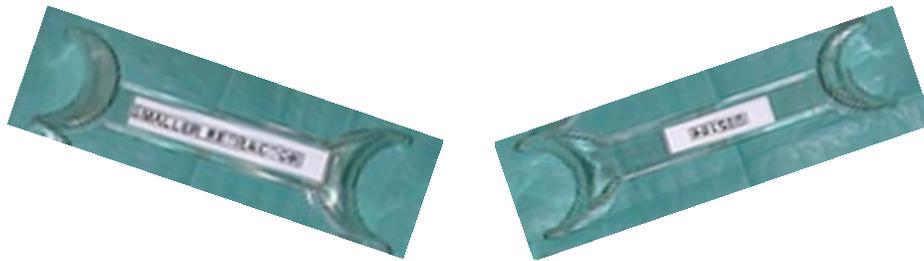


Upper Occlusal - Mirror

Here, the dental mirrors come into play. The assistant now switches to the *smaller* retractor set and with the patient's mouth held open, the retractors are inserted in a "V" shape to retract the upper lips *sideways and away* from the teeth. The clinician inserts the mirror with its wider end inwards to capture maximum width of the arch posteriorly, and pull it slightly downwards so that the whole upper arch is visible to the last present molar. The patient may be instructed to lower their head slightly so that the shot can be taken 90° to the plane of the mirror for best visibility. It is recommended that the mid-palatal raphe is used as a guide for the orientation of the shot to get it leveled. Minimum retractor show in the image is



recommended, and no fingers should be visible at any time.



Lower Occlusal - Mirror

The final shot in the series. The assistant would now lower the smaller retractors into a *Reverse "V"* shape to retract the lower lips sideways and away from the teeth. The clinician would now lift the mirror upwards so he/she may visualize



"Ideal" Shot - Tongue Rolled Back



"Less-than-Ideal" Shot - Tongue Visible But Not Obstructing View

the reflection of the lower arch, while the patient is be asked to "lift their chin up" slightly. Ideally, the shot should be taken 90° to the plane of the mirror, with the last molar present visible. An important issue here would be the tongue position of the patient while taking the photo. It is best to ask the patient to "roll back"



their tongue *behind the mirror* so that it won't interfere with the visibility of any teeth, particularly in the posterior area.

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The following images reveal in a more visual way some important aspects of Clinician/Assistant positioning, as well as retraction technique during photographic record-taking.



Upper Occlusal Shot



Lower Occlusal Shot

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Position Of Retractors For *Upper* Occlusal Shot



Position Of Retractors For *Lower* Occlusal Shot



**Right Buccal Shot:
Clinician Holding Narrow-End Retractor On Side To Be
Photographed.**

Helpful Tips

- The direction of pull of the retractors is always sideways and slightly forward, away from the gingival tissues. This maximizes the field of view and minimizes patient discomfort.
- Wetting the retractors just before insertion eases the process of positioning them properly with minimum patient discomfort.



- When taking occlusal “Mirror” shots, slightly warming the mirror in warm water prior to insertion helps prevent “Fogging” of the mirrors which would prevent a clear image.

- In certain cases, profuse salivary flow and “frothing” can affect the quality of the image being taken, thus a saliva ejector can be used to eliminate saliva prior to taking each photograph.
- During occlusal “mirror” shots, instruct the patient to “open wide” *just prior* to pressing the camera button. This helps in obtaining the maximum mouth opening at the right moment, and minimizes the patient’s fatigue during the procedure.
- It is recommended that all photographic records be taken *before* impression-taking, to eliminate the possibility of impression material being stuck between the teeth or the face during photographic record-taking.



5. The “After-Shot”: Post-processing Your Digital Images

Image-Editing Workflow

Once all photographs have been taken, the next step involves downloading them to a computer for some (hopefully!) minor editing and image correction in preparation for saving and storing them on the hard drive, either in specific folders created by the user, or inside a dedicated database within a proprietary orthodontic imaging software.

Downloading Images to Your Computer

Images from your digital camera can be downloaded to your computer through either a *USB* connection, or the faster *Firewire* port present on some high-end PCs. Once the images are downloaded to a folder, it is good practice to **immediately back-up** that folder (with proper name and date) to another hard drive or removable media i.e. CD or DVD.

An immediate back-up ensures you have a complete back-up of all the original, unprocessed image files in case anything goes wrong during processing.

Once that is done, you are ready to start editing your images using a suitable image-editing software. The most well-know software for image-editing is *Adobe Photoshop*. Also *Corel's Paint Shop Pro* is another full-featured option. However, for most orthodontic purposes, only basic editing functions are required to enhance most images before saving them, and thus a fancy (and often expensive) software is not required. In fact, there are a number of free software programs on the internet that can be used easily and effectively for our purposes. Some recommended programs include - but not limited to - the following:

- **Microsoft's Preview** (bundled with Windows). It has all the basic functions for rotating, flipping, cropping, and enhancing the color and brightness of digital images.

- **Paint.Net (Windows):** It can be considered a slimmed down version of Adobe's Photoshop. It has some more advanced features like layering and filters, in addition to the basic functions.
- **Fast-stone Image Viewer (Windows):** Another free piece of software that has most of the necessary functions as well as containing a simple and efficient library manager for organizing your photos into albums.
- On *Apple's Macintosh* computers, the built-in "**Preview**" can also manage all the basic editing functions required. The bundled "**iPhoto**" can also do the same, and can make managing patients albums an easy and fun task. "**Pixelmator**" is a more advanced editing software that can also be considered a slimmed-down version of Adobe's Photoshop for Mac.

Editing with Image-editing Software

For most orthodontic purposes, there are only a few number of editing procedures to follow to obtain the best possible end-result. These procedures include:

- **Flipping (Mirroring) and De-rotation**, either vertically or horizontally.
- **Cropping**; removing unnecessary image "information".
- **Color, brightness and contrast** enhancement.
- Selective "**Scratch Removal**".
- **Saving image files.**

Flipping (Mirroring) and De-rotation

This should be the first step in editing the images. The purpose is to re-orient the image properly vertically and horizontally, and relative to the occlusal plane or mid-lines of the jaws. Frontal and buccal intra-oral shots should be level with the occlusal plane of the teeth. Upper and lower occlusal shots should have a leveled mid-sagittal plane e.g. The mid-palatal raphe should be in the midline of the image. These planes should be leveled ideally when taking the photos, but a small amount of correction usually remains needed. Upper and lower occlusal



De-rotation

shots (Mirror) shots usually require vertical, then horizontal flipping to correct their orientation, followed by a degree of de-rotation (See Images above).

Cropping

The second step in processing the images. Its purpose is to remove all and any unnecessary parts of the image that are not required for a good image quality. This includes most of the cheek retractors, lips and fingers if present within the original image. Cropping is easily achieved by selecting the “crop” tool within the image-editing software toolbar, and selecting the area that you require to keep. The software automatically “discards” all other image information outside of the selected area (See example below).



Choosing Area to Crop



Cropped Image

Color, Brightness, “Gamma” Control & and Contrast

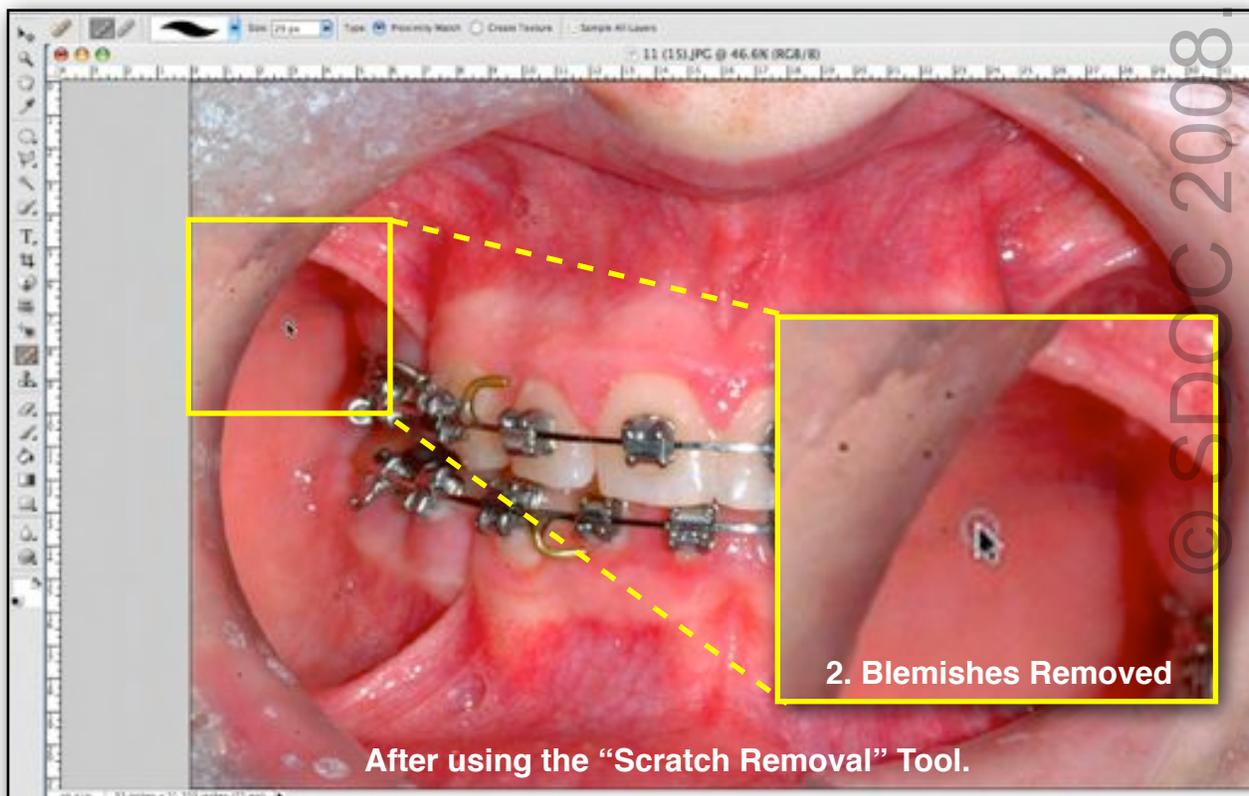
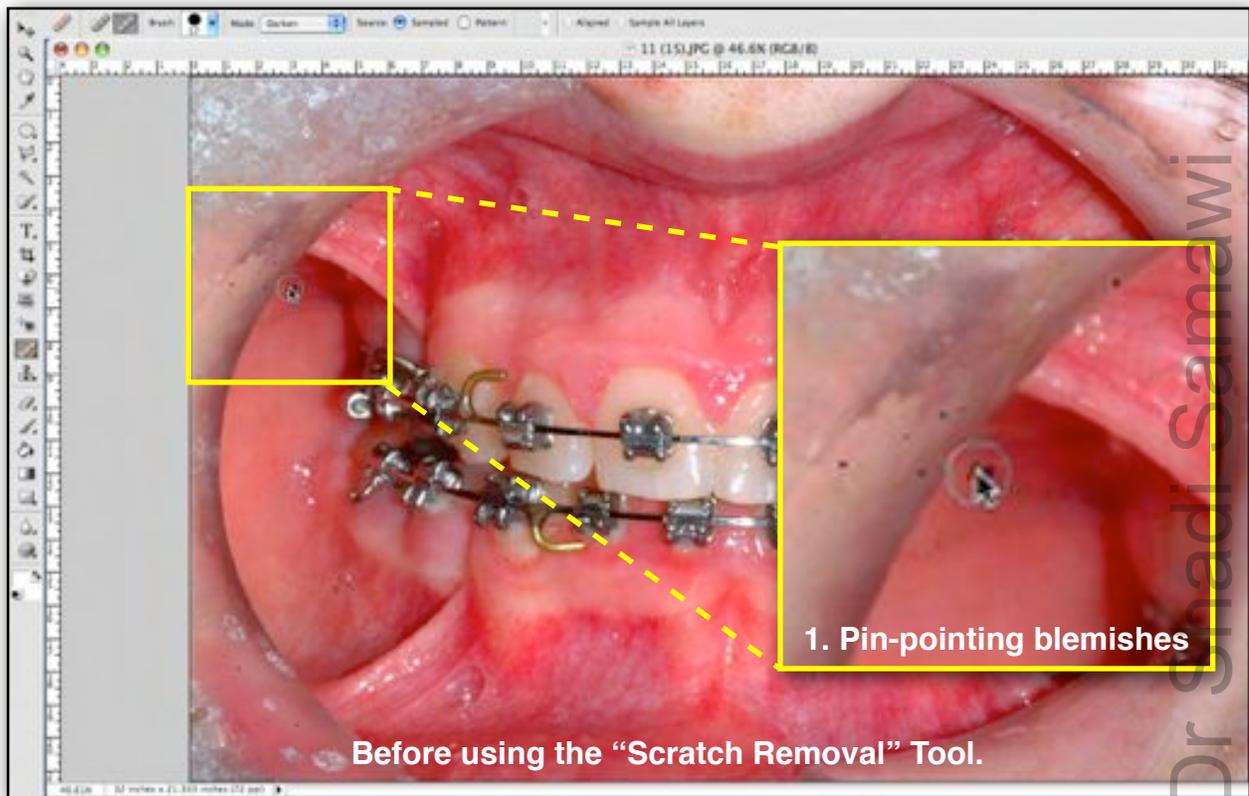
Occasionally, images may require slight adjustments in their brightness/contrast values to make them more defined and in conformity with the rest of the images of the photo set. For even quicker adjustments, the “Exposure” and “Shadows/Highlights” controls may be used, depending on the image-editing software being used. These controls can help minimize or even eliminate some dark shadows and the “dull” appearance of images. The “Gamma” control is also a good alternative for both the “Brightness/contrast” controls combined. There are no specific adjustment recommendations here as the adjustments to be made are very subjective and variable depending on how the original image has been captured, and the operator’s preference and/or requirements.



“Scratch” Removal

Sometimes dust particles become attached to the camera CCD sensor, or minor scratches occur on the mirrors used for occlusal shots. These will appear on the final image as a “scratch” or dark blemishes scattered around the image and detract from the final quality of the the image. These can optionally “removed” using the “scratch removal” tool that is found in some image editing software

tools. This tool is sometimes called the “Healing” tool. The “Cloning” tool in



certain software suites can also do a reasonable job of removing blemishes and dust shadows from images.

Saving Your Images

After the image enhancement part is accomplished, it is time to save the enhanced version, either in a dedicated folder for each patient and set of photos - labeled by date for example - or within a proprietary orthodontic imaging software database if available.

There are many image formats to choose from, however, for practical purposes, we require only two main formats to effectively deal with storage and “working” images respectively, and so we shall briefly mention two formats;

1. **Tagged Image File Format**; commonly known as **TIFF** format.
2. **Joint Photographic Experts Group** Format, commonly known as **JPEG** format.

Tagged Image File Format (TIFF)

TIFF is a “loss-less” compression format i.e. No loss of quality occurs when saving files in this format (no data is removed to reduce the file’s size). Therefore, this is the preferred format for saving backup copies of your original image files, before manipulation. This way, you will always have a high-quality copy of the original file in case anything goes wrong during the enhancement process, or in a case of a computer crash!

The downside of this format is that it results in very large file sizes as no data is removed upon saving the file. Thus, large capacity hard drives are required to maintain storage of these backups, or alternatively, they can be regularly archived onto removable media such as CDs or DVDs, and filed according to patients’ names or date of capture.

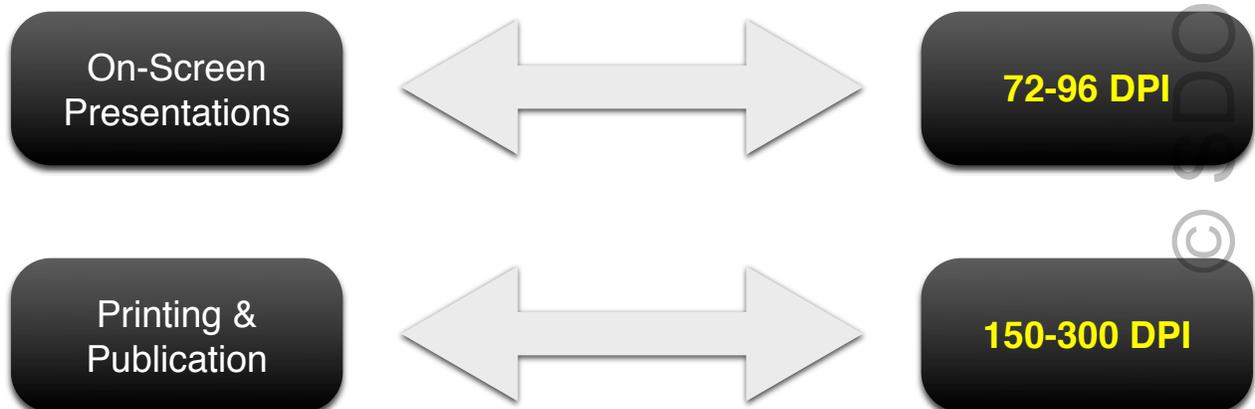
Joint Photographic Expert Group (JPEG)

This format may be considered as the “working” image format that can be used for performing the necessary image enhancements. It is a “lossy” compression format which means that every-time the image is saved, some image data loss occurs in order to maintain a reasonable file size, ultimately resulting in some degree of sacrifice in quality of the final image.

Saving your final images in JPEG format is recommended as these images will be accessed frequently by the clinician, and may also used for presentation purposes.

Saving Images for Publications and On-screen Presentations

For images that will be used in on-screen presentations or the web, it is not necessary to include very high-resolution images, as this will mean a larger file size and ultimately long loading times and slow performance overall. The recommended resolution for such images is in the range of **72-96 DPI**. For printing and publication purposes, the resolution should be higher, in the range of **150-300 DPI**. This is to allow for higher quality printing with no “pixelation” of the images in print, especially when enlarged.



6. References & Resources

Note: Some images used in this short guide have been adapted courtesy of some of the following resources.

Books

1. *Orthodontic Pearls: A Selection of Practical Tips and Clinical Expertise*; Eliakim Mizrahi. (2004) Taylor & Francis Group. (Chapter 4: Orthodontic Photography, by PJ Sandler, AM Murray)

Articles

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Websites

<http://www.thedigitaldentist-site.org.uk>

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Dr Shadi Samawi
BDS, MMedSci, MOrthRCS
Specialist Orthodontist

Samawi Dental & Orthodontic Center
Amman, Jordan