A colour-managed workflow for clinical photography

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Updated March 2018

Last updated March 2018

Introduction

This paper describes a process for controlling the colour in the clinical photography workflow. Control is the key word here – I am a terrible control freak when it comes to digital processes and I hate it when my camera, PC, printer or anything else does something with built-in processes in which I have no say.

When we consider how a colour-managed workflow can be brought into clinical work we need to examine how feasible this is, how expensive and complicated is it and how it can be integrated into, or even replace existing processes.

So why do we need it? Well, this is why:

What you see across this page are three camera-generated JPEG images of exactly the same subject under exactly the same lighting, but from three different camera manufacturers. These are images that the camera will give you if you set the white balance to 'Flash' and shoot in JPEG setting at a 'High' or 'Fine' quality.

Apart from that, you have no control over the process. And it doesn't matter which model camera from which manufacturer; it wouldn't even matter if this were three different models from one manufacturer, they would all give different end results.

So which is correct, or which is most correct? It could be any of them, but most likely it is none

of them, because the camera is deciding what to do. And that is the major issue here, because this means that if we shoot in camera-JPEG mode, we are producing colour in our clinical images that is no more accurate than a non-professional could produce. So if we put ourselves forward as a profession – where we strive to work to the highest professional standards – then we ought to be more in control, and achieve more accurate and more consistent colour in our clinical work than anybody else can achieve.

So what I am describing here is a process by which you can still have a JPEG-format image as the end result – as really that's what we are all after: a finished, high quality image of reasonable size for uploading and/or storage, but one whereby *you are in control* of the colour, contrast, size, quality, colour space and all the other parameters in that image.

I am also a great believer in automated processes which can really cut down on the time you spend in front of a screen, so this workflow uses automation wherever possible.

Now this process assumes that everyone will have either Photoshop from version CS6 onwards or Lightroom. It helps to have a much more up-to-date version of Photoshop than CS6 but what I am describing will be valid for that version too. Though as you will see, Photoshop itself actually plays no part in the process at all.

Get the basics in place

The basic components that are required are:

- calibrated monitors;
- white balance set to a known grey standard;
- all cameras profiled.

Now that last point is crucial because profiling the cameras means that you can eliminate as much as possible the variances between camera manufacturers and between different models from the same manufacturer. So even if you have Nikon XYZs at one site and earlier Nikon ABCs at another, or someone drops their Canon and it has to be replaced with a later model, making a profile for each camera will give you very standardised results from all the sensor variants. They won't be identical – colour management is never that precise – but the variances will be significantly reduced. And the whole point about colour management is that each and every device has to be **profiled**, or **characterised**, so that its specific behaviour can be determined and mapped.

There is one factor though which a lot of people will baulk at and that is the fact that in order to use a colour-managed and profiled workflow, you have to shoot in **raw** format. Now this is the point where a lot of photographers will reject the concept, assuming that storage space is a show-stopper, or that editing raw files is complex or too time-consuming.

But while transferring raw files from camera to PC will be slower than transferring JPEG files, this and other objections can be overcome very easily. In fact, this proposed workflow is extremely quick as it is based on defined presets and batch processing.

Monitor calibration

Firstly, your monitor has got to be calibrated properly. If you are editing images on an uncalibrated monitor then there is no way that you can be sure that what you are viewing is accurate and it is not difficult to have calibrated monitors. Obviously you can buy self-or hardware-calibrating units from Eizo and NEC; these are expensive but they are excellent

monitors and are highly recommended. But they're not the only choice and there are excellent, less expensive models from both these manufacturers as well as BenQs, Dells and others, which can all be calibrated very well with devices such as the **X-Rite i1 Pro**. You only need one of these – they're about £200 – but the software can be put onto each machine and the monitor recalibrated about once every three months. I also recommend monitor hoods for every monitor on which you are editing images. They really keep down the effect of ambient light.

Grey reference cards

You need a good grey card from a reputable source – the **X-Rite ColorChecker Passport** (below) is ideal as it has a grey patch built into it as well as the colour patches you need to profile your camera. They cost about £85 and you only need one of them to do the profiling as the software can be run on any computer.

Items to avoid at all costs are old Kodak 18% grey cards [A, opposite page] as these were made for density rather than neutrality – they

are only for an aid to exposure. Similarly, the old Kodak grey step wedges [B, below] should never be used as again these were CMYK-printed to enable the creation of characteristic curves and they show a wild variance of greys. If you click on each patch you will certainly get a different value every time so do not use those.

Speed

Transferring raw format files is obviously slower than JPEGs as the files are much larger, but for modern high-speed SD cards on a PC or Mac with a good card reader connected via USB3, Thunderbolt or similar, we are talking a few seconds difference. If you shoot 35 images of a patient, transferring those files in JPEG format will probably take about five seconds. Transferring 35 raw format files on a good PC was achieved in around 10 seconds (see below); that's three raw files per second and transfer speeds were over 90 MB/s. This is attainable fairly easily so it is doubtful that any major hold ups will occur at that stage.

Once you have the raw format files in front of you, you can take complete control over the
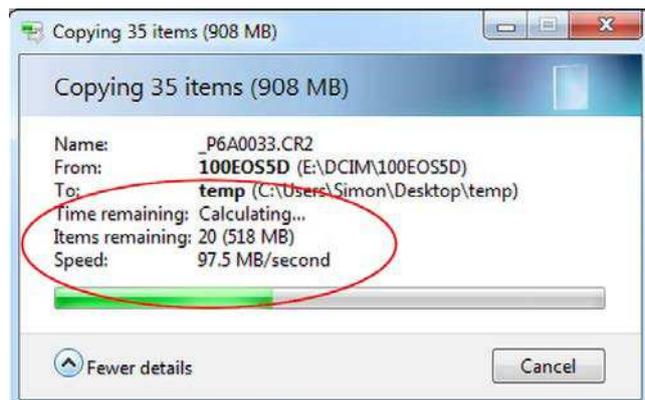
final images. This stage can be made simple and straightforward and your files can be batch processed in a matter of a few seconds, giving you *controlled*, as opposed to *uncontrolled* JPEG images. That's the key difference as compared to JPEGs made in the camera.

The camera-generated JPEG image

It is worth remembering what a camera is doing to an image when you shoot in JPEG format (see flow chart below). The camera applies a white
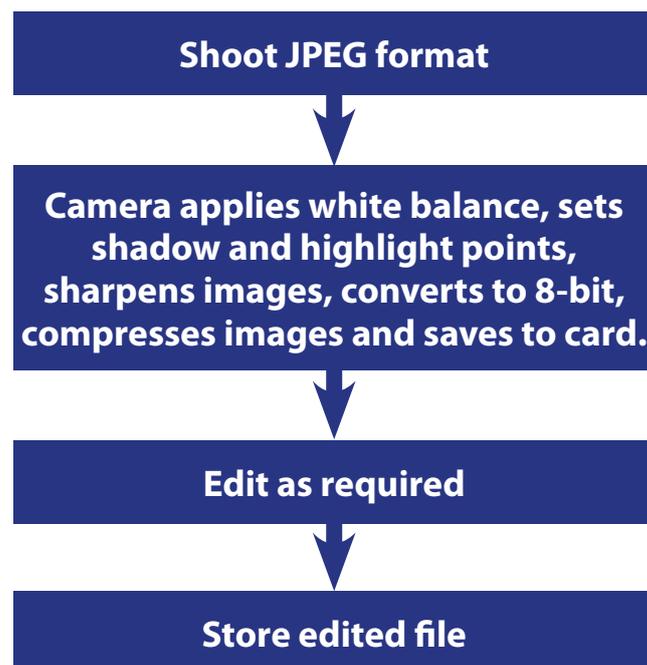
balance according to the setting you specify – flash, daylight, tungsten, or even 'Auto', which is probably the most dangerous setting of all. It then sets shadow and highlights, adjusts the contrast and dynamic range, it applies sharpening (which you cannot adjust at all) converts to 8-bit sRGB colour and compresses the data according to the Basic, Normal or Fine setting that you have specified. That then gets saved to the camera card. If you want to edit that you can do, but you will be limited as to what you can do with that image in terms of improving quality and every time you save it in JPEG format you will be throwing away yet more data.

What we are looking at is to shoot in raw format and acquire the raw files into Adobe Camera Raw (ACR) or into Lightroom, depending on your

Shoot Raw format

↓

Acquire into ACR/Lightroom and apply profile. Edit (non-destructively)

↓

Batch export in required format with assigned parameters.

↓

Upload/print, store or dispose or raw file.

preferences. A profile which you have built for each camera can then be assigned automatically and further minor edits can be done if required. You might want to crop or straighten an image fractionally. You might have some mirror views which need brightening by half a stop. You will have far more latitude doing that in ACR than you would with a JPEG image and it is non-destructive.

You can select the images you want or reject those that are duplicates or not needed. As with any raw workflow you are postponing any image processing until you're happy with it.

All the selected images are then batch-exported to JPEG format to the size and quality level of your choice and, again, these parameters can be saved as presets so that it really does come down to a matter of a few clicks. You then get your choice of JPEG file and you can choose to store or dispose of the original raw files.

Building profiles, defining presets

Let's look now at how you get those profiles and save the presets for use. You shoot a frame of your grey reference and then another of the colour patches. This is why the X-Rite Colorchecker Passport is recommended as everything is there and the software is freely downloadable for PC and Mac.

This is what the Colorchecker Passport software looks like. The software requires a DNG-format file so you will need to convert the colour patches image to DNG in Camera Raw or Lightroom. This does not imply that you have to convert all your raw images to DNG (though you can if you want and there are good reasons for doing that) but it is not necessary routinely – just for this initial process.

Open the Colorchecker software (above) and drop in or open the colour patches file. It puts a grid over the patches, which you can adjust if it doesn't get it completely right, although normally it is pretty spot on. Make sure you don't over-expose because if there are any clipped colours, it won't be able to process the image properly. Once it's set, click *Create Profile* and it will do just that and save the profile for use in ACR or Lightroom.

It is worth stating here that this profile describes the action of a **specific illuminant** on a **specific camera sensor**. You can do this with flash, daylight, tungsten, fluorescent or even mixed lighting. The Colorchecker software even allows dual-illuminant profiles to be built but that is not covered in this document. A profile for studio flash will probably never change and if you create a profile for daylight, don't worry about the time of day that you do this. The reference grey can be used to adjust for different colour temperatures at different times of day but the illuminant, i.e. daylight, remains constant.

Neutralise to grey

Next, open the image of your reference grey in ACR along with a series of typical clinical images too. *Select All* in Camera Raw but have the grey patch as the visible image and you can see it


here. Select the **grey dropper tool** (top left of the ACR screen) and click in or draw a rectangle in the neutral grey area. This is *essential* as the first step. This sets the colour temperature and you will see on the right of the window that in this case the CT is set at 5100K with a slight magenta bias.
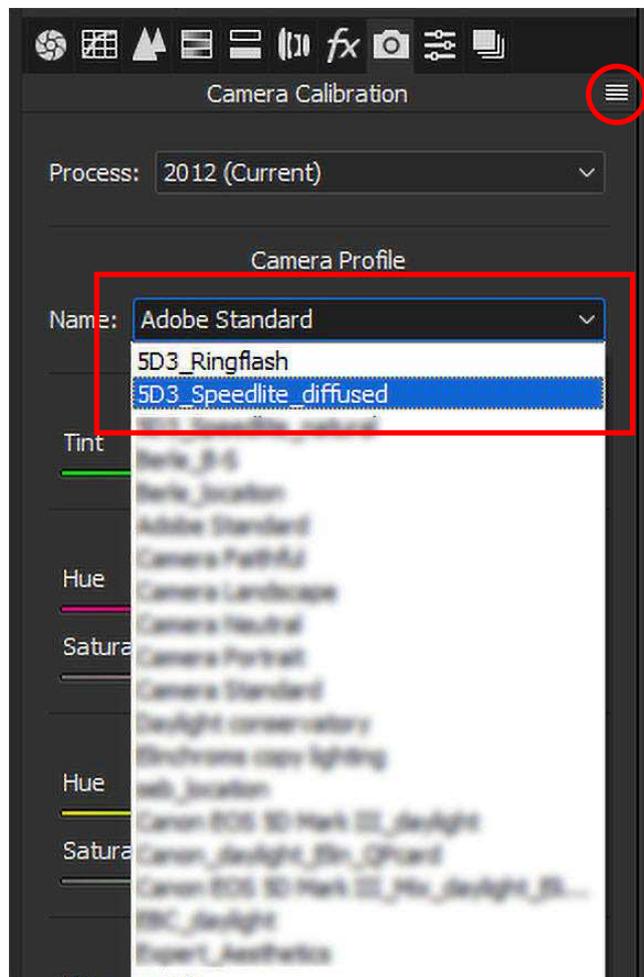
You then select the **Camera icon** on the control panel (circled above) and this shows you that at the moment, as a default, a profile called Adobe Standard is applied to your images. However, clicking the drop-down will show you the new profile that you have just created and named with the Colorchecker software.

So in this example (left) I am selecting a profile I have created for my Speedlites with a diffuser and, as I shoot virtually all my work using this, I can select the **Options** tab at the top and Save these as **New Camera Raw defaults** (next page). This means that all raw images will have that colour temperature from the grey card and the profile settings that we created applied automatically, every time.

You can then go back to some of the clinical images, maybe adjust black or white points – you might have an all-white studio, so a tweak to the contrast setting or reduce the highlight
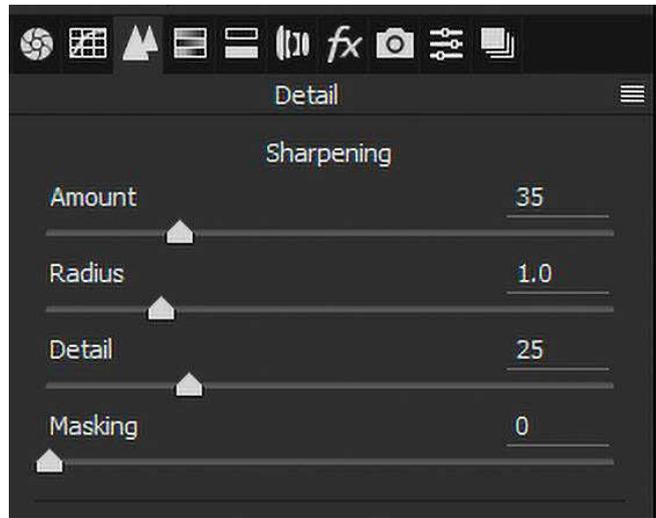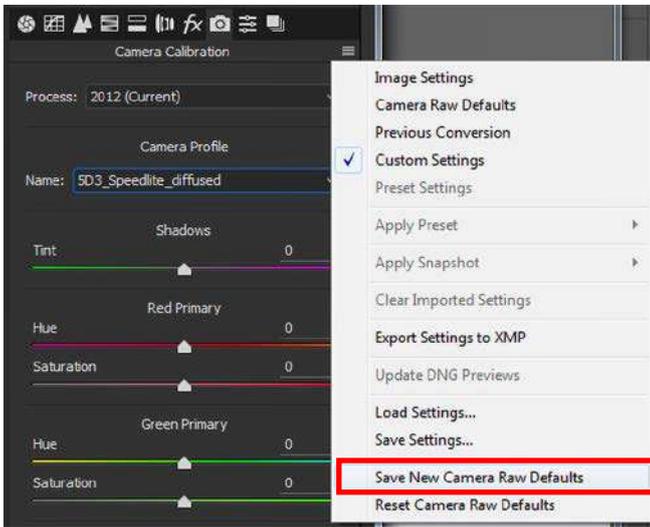
setting by a couple of notches (see left). You can make sure that Lens Corrections for the lens that you have used is checked so that ACR will apply those corrections automatically (bottom left).

You might want to adjust the level of sharpening that ACR applies to raw images (above) – every image needs input sharpening to counter the inherent softness of the sensors and most of the time you have no control over that at all, but you can do in ACR. Adjust until you are happy with these settings as standard and then Save as Default again.
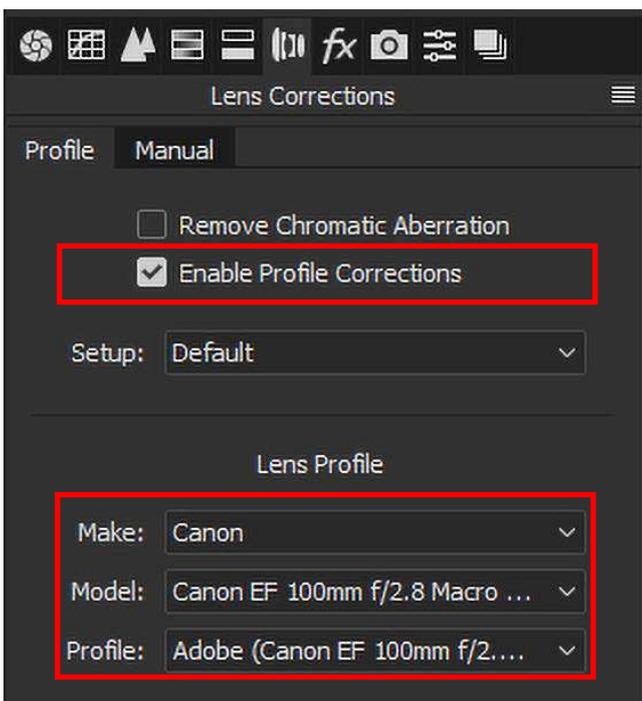
You can even ask ACR to make defaults specific to individual cameras (below) so if you have different models and have created a profile for each – which is the whole point of this workflow – then ACR will apply defaults accordingly.
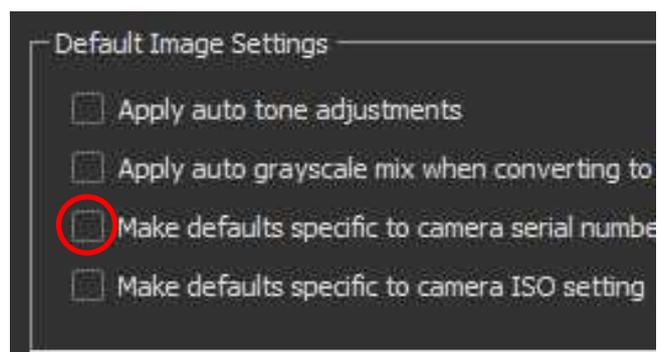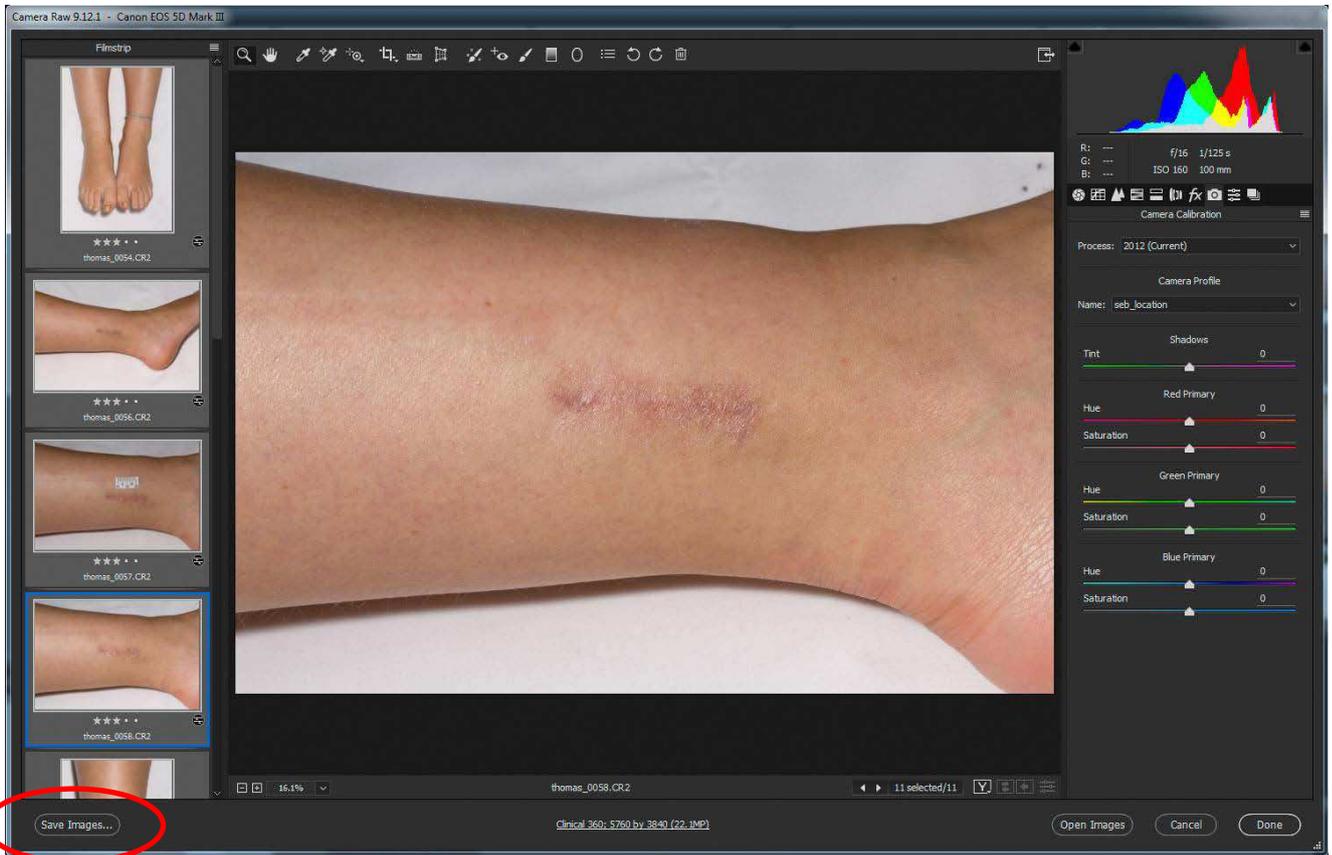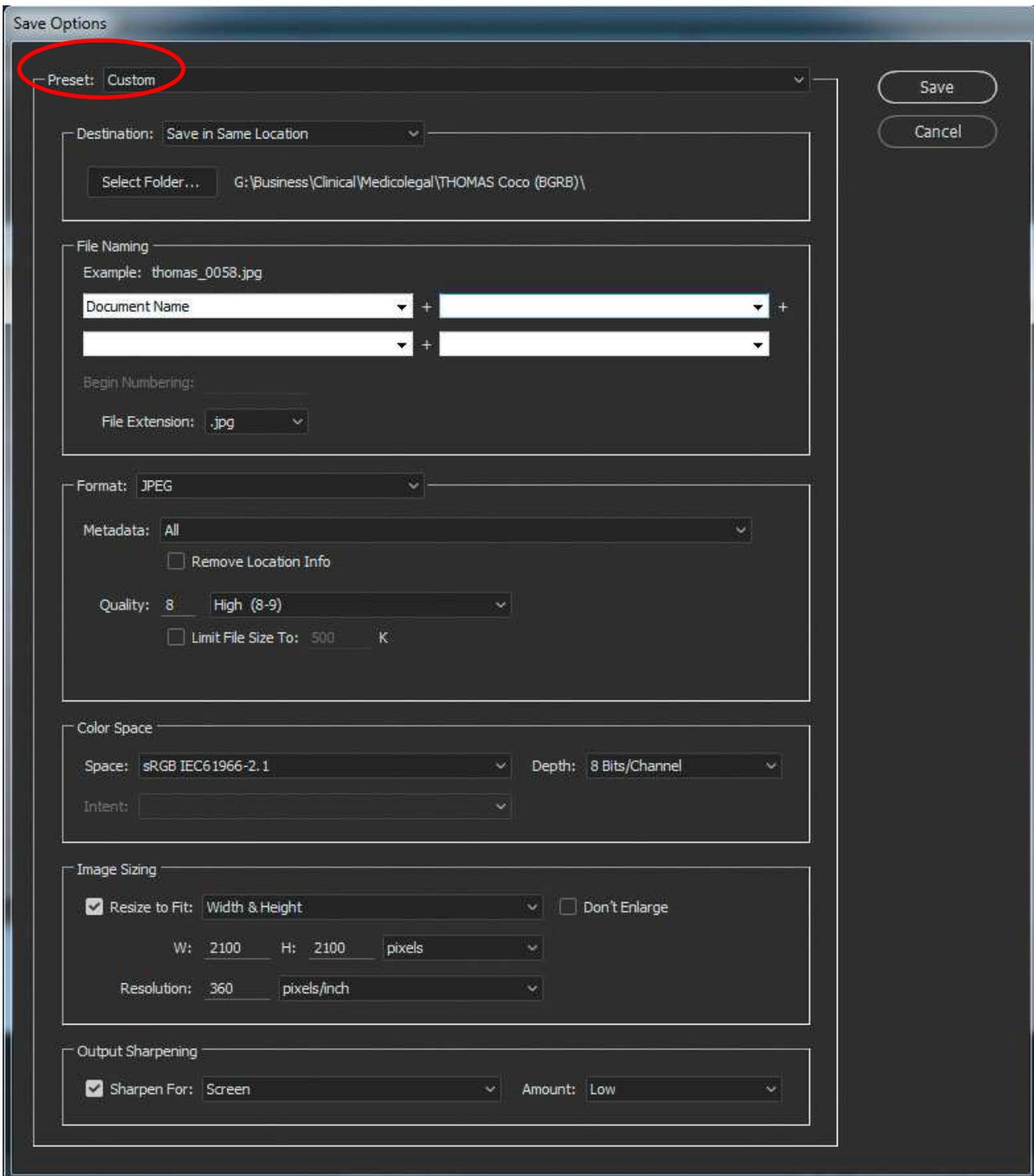
Saving to your chosen format and settings

So at this point we have raw images, all neutralised to a known colour temperature, all with a camera-specific profile applied, so now we can use yet another preset to save the images where we want them and in the format we want them.

In Camera Raw (above), select all the images you want and click the *Save Images* button (circled).

You get the Save Options panel (above) which allows you to specify:

- the file format: shown as JPEG above now though you can also choose DNG, PSD or TIF;

- the quality (the usual scale of 1-12 seen in Photoshop) and you can specify a maximum file size;

- the colour space and bit depth: normally sRGB and 8-bit for exporting to JPEG;

- the image size so you can have a standardised pixel dimension size;

- whether any output sharpening is applied and how much;

- where the files should all be saved. This will probably be either along with the raw originals or you may have a specified upload folder for sending the images to your Trust image database or your own file servers.

You can save all these choices as another Preset so they can all be invoked again with just one click. (See **Preset** at the top of the Save Options screen)

See process chart below.

1. Shoot a raw image of both your grey reference and the colour patches.

2. Convert the colour patches to DNG and build a profile. Name and save it.

3. Get yourself a series of typical clinical images, neutralise to your reference grey and apply the profile, then adjust minor settings such as highlight, black, white or contrast in ACR and then save your settings as New Camera Raw defaults.

4. So then when you acquire the raw images from a patient you get accurate colour applied automatically, you can still tweak individual images and batch save the whole lot to your JPEG settings, in the location you want very quickly indeed.

> **Shoot raw images of grey reference and colour patches (to DNG)**

> **Build profile using X-Rite's Colorchecker Passport software. Name and save it.**

> **Acquire a range of raw files to ACR/Lr. Neutralise to grey and apply profile. Adjust other settings. Save as default.**

> **Acquire clinical images. Check settings, batch-export in required format to selected destination.**

What do you need to do this?

You need **Adobe Camera Raw** which comes with Photoshop and is invoked either through Bridge. This is the recommended route, as you can select the images you want and immediately invoke ACR or you can also get into ACR using the Open command in Photoshop.

An alternative is **Lightroom** which some users prefer. It doesn't have the editing capabilities of Photoshop but for this workflow you don't need it. As you have seen, you don't actually open any of these images in Photoshop – it is all done with the raw processor.

You need **fast cards** and an **up-to-date interface** to acquire your images. Those are not expensive.

You must have a **calibrated monitor**, either self-calibrating or with an **X-Rite i1 Pro** and you need to get yourself an **X-Rite Colorchecker Passport** with has both the reference grey and the colour patches in it.

None of these should break the bank. It requires a bit of effort to implement and produce the profiles but you can immediately expect higher, standardised quality and increased speed in your clinical workflow.

On-line resources for training in Camera Raw and Lightroom are shown on page 15 of this document.

Saving Camera Profiles

Profiles generated by Colorchecker Passport have a ".dcp" suffix and should be stored in the following locations:

Windows:
C:\Users\<name>\AppData\Roaming\Adobe\CameraRaw\CameraProfiles

Mac OS:
Application Support > Adobe > Camera Raw > CameraProfiles.

Using Adobe Lightrooom CC

The raw file processor built into Adobe's Lightroom CC application is also Camera Raw, so the functionality is identical, just presented slightly differently.

Look for the Camera Calibration tab in the Develop Module (see right) and any DNG profiles that you have defined with the Colorchecker system as described in this document will be listed in this drop-down menu. In the example below, the "seb_location" profile is being used and this will be applied to all or as many images as are selected in the applications.
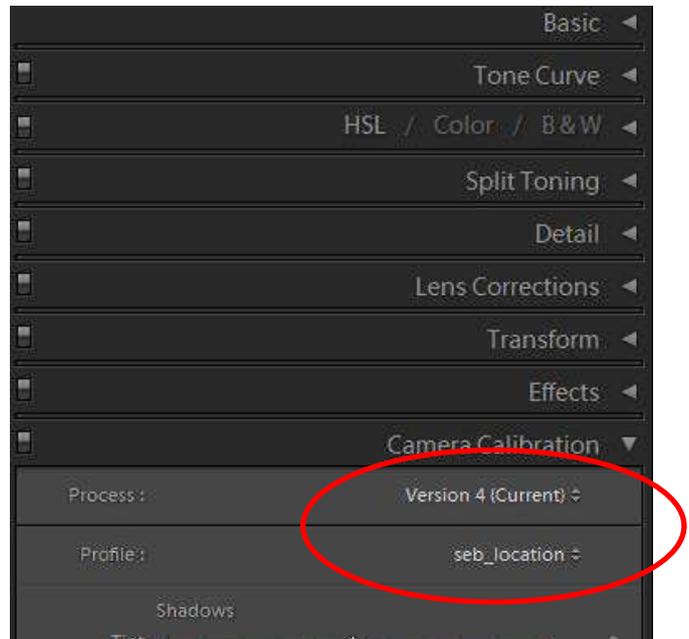
Lightrooom's Export module

Exporting images to the chosen format from Lightroom is as straightforward as it is in ACR. Selecting **Export** in the File menu brings up the Export options (below) and here you have a range of options (in drop-down menus) similar to those described previously for ACR:

- **Export Location**: either along with the raw originals or you may have a specified upload folder for sending the images to your Trust image database or your own file servers;

- **File (Re)naming** if required;

- **File Settings**: the format, quality (if applicable), colour space and a file size limit;

- **Image Sizing**: resize if required to a specified image size so you can have a standardised pixel dimension size and resolution;

- whether any **Output sharpening** is applied and how much;

- save all these choices as another Preset so they can all be invoked again with just one click. (See Add or Remove Preset in the top-left panel of the screen)
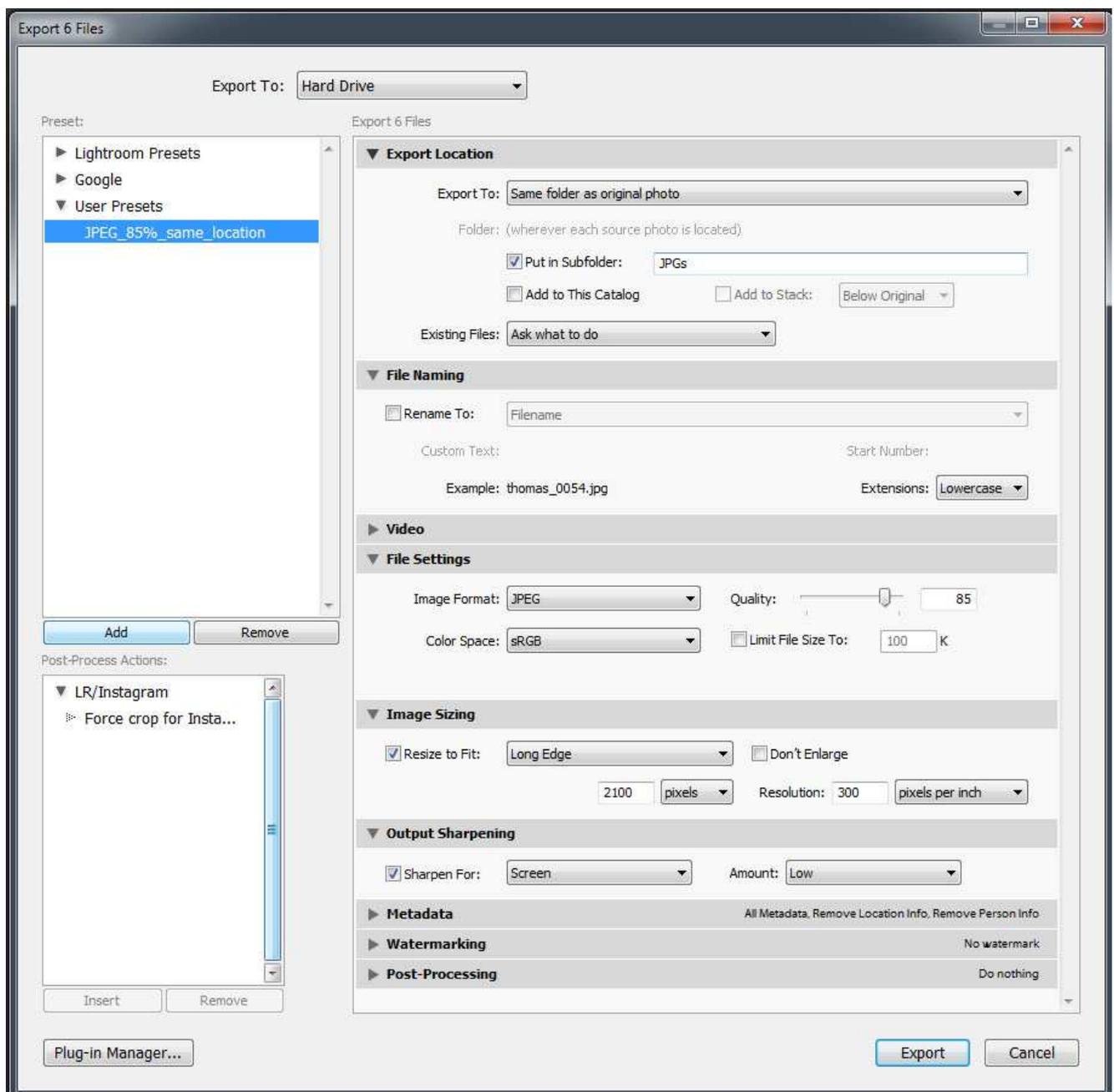
Update for Adobe Camera Raw v.10.2, February 2018

One minor irritation with Adobe Camera Raw was the fact that if you shot a mirror view – and this is very common for dental photography – then you had to bring the image into Photoshop in order to flip the image either along the **horizontal** axis (as you would for a mirror view of the upper arch) or along the **vertical** axis, for pictures of lateral/buccal views.

In mid-2017 I submitted a Feature Request to the Adobe Camera Raw team and in a remarkably short time frame they came up with the answer. But you need to know the secret key combination to access it…

Firstly, make sure that your Adobe Creative Cloud app (ACC) has delivered the update to ACR. You should have version 10.2.1.895 or later. To check, open any raw-format image in ACR and then use Ctrl-K or click the Preferences icon at the top. The version number will be shown at the top of the Preferences screen, as seen here.

ACR update Feb 2018

Camera Raw Preferences (Version 10.2.1.895)
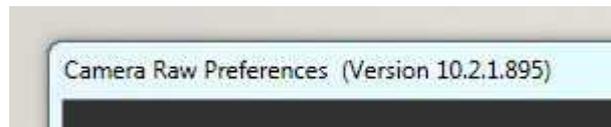
If you have an earlier version, you will need to get the update through the ACC application (Check for App Updates) and ensure that you have this version or later.

With an image open in ACR, you will that the usual set of icons across the top looks like this, with the Rotate Left and Rotate Right icons at the far right.

Press the Alt key (Windows) or the Opt key (Mac) and they change…

…into the Flip on Vertical Axis (i.e. flip left-to-right horizontally) and Flip on Horizontal Axis (i.e. flip top-to-bottom vertically) icons. So now you can take your mirror views of the upper arch, or mirrored lateral buccal views and re-orientate them using the Flip keys in ACR without having to take them into Photoshop.
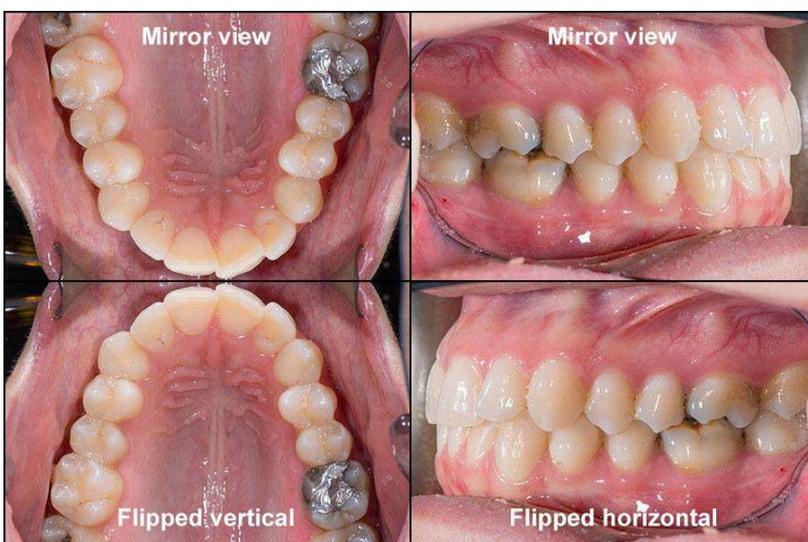
Many thanks to the Adobe Camera Raw team for implementing this Feature Request and to colleagues at Birmingham Dental Hospital for these example mirror images.

Using Adobe Camera Raw

Adobe Camera Raw (ACR) comes as part of the Photoshop-plus-Bridge package and is also the raw image processor built into Lightroom. It is a very powerful raw converter and image processor and all the process steps are held as a separate XMP file; the raw image file itself is never altered. It is only when the image is finally processed and exported to a bitmap format, such as PSD, TIF or JPEG, that the edits are committed. Even so, the user can return to the unmodified raw file at any point and re-edit the image as required.

ACR is able to import raw-format files from a considerable number of digital cameras and Adobe updates the application at intervals to include newer camera models and new lenses. However, there can sometimes be a significant time gap between the release of new cameras or lenses and these being incorporated into the latest ACR update.

It is worth spending time getting to know ACR well and how to adjust the various settings. Some of the adjustments are not relevant to clinical work but time spent understanding and adjusting the histogram settings and the raw sharpening is well worth the effort.

There are plenty of training videos available on the web, including Adobe's own tutorials site. Here are some links to some of these training resources. No endorsement of these resources is intended by listing them here.

Adobe: As the creator of the Camera Raw software itself, this is a good place to start: https://helpx.adobe.com/uk/photoshop/how-to/camera-raw.html and also enter '*Camera Raw*' into the Search box under the Adobe Tutorials for more material.

Andrew Rodney: http://www.digitaldog.net/ Several useful video tutorials here, some a little dated now but still useful.

Adobe's tutorial site

Phlearn: https://phlearn.com/tutorial/how-to-use-adobe-camera-raw-in-photoshop/

Lynda: www.lynda.com This subscription site has an extensive range of training videos covering Adobe's entire software range as well as numerous other training topics, both business and social: search the site for '*Camera Raw*'
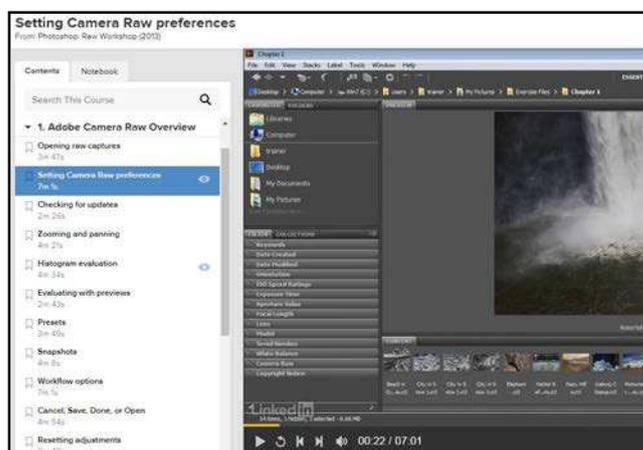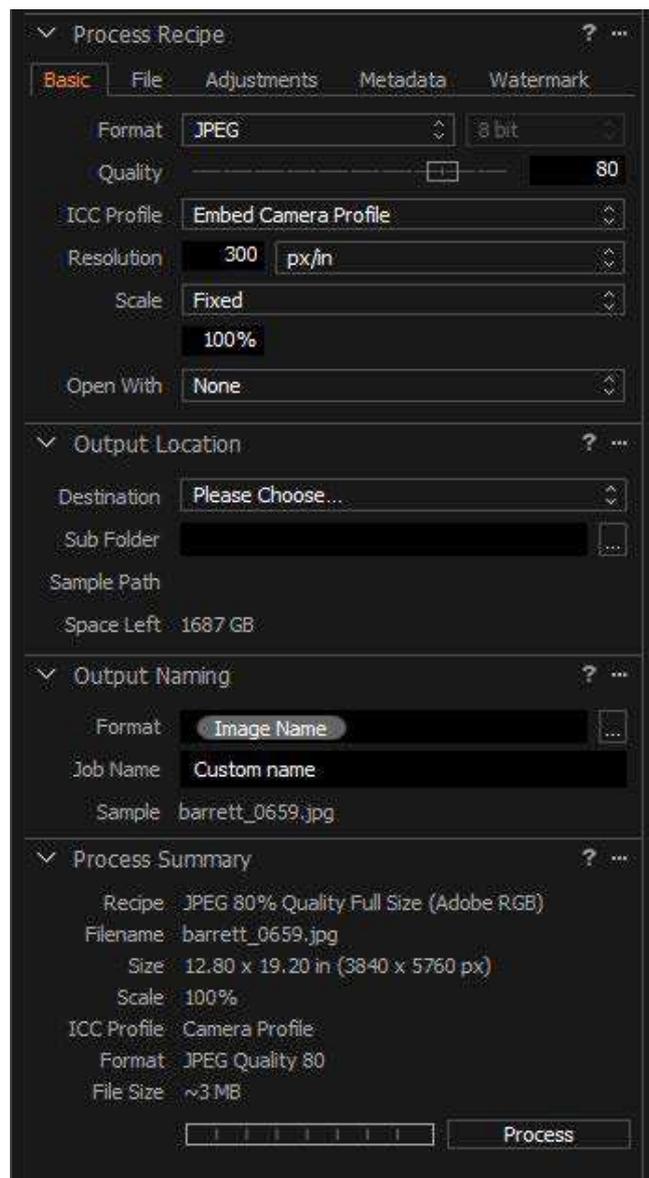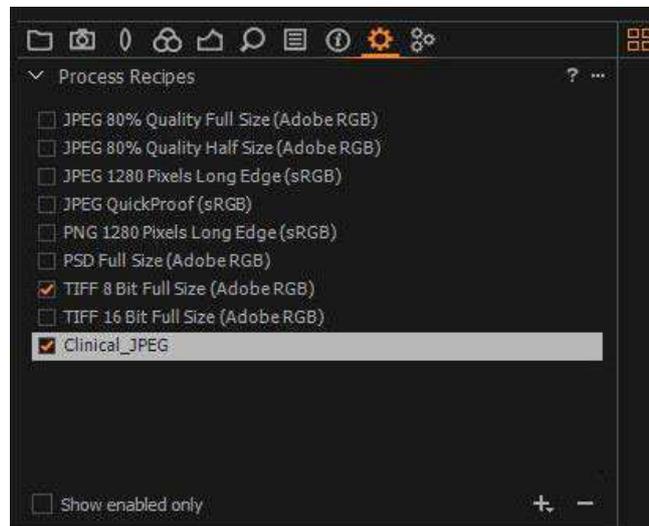

Lynda.com: Camera Raw overview

Phase One's 'Capture One Pro' application

Capture One Pro is one alternative to Adobe's Creative Cloud applications and is used by some Departments of Medical Illustration.

It has many similar features to the work flow described in this document and the Export functions are known as 'Process Recipes' and can be saved in the same way as Presets can be saved for ACR or Lightroom (see opposite).

The one difference, however, is that Capture One does **not** support the use of DNG camera profiles, so it cannot be said to be part of a fully-colour-managed work flow. Phase One supply generic profiles for many camera models, certainly for all the modern SLRs, but these cannot be modified to match an individual camera's sensor characteristics under a specific illuminant. That is not to say that Capture One is unsuitable for medical work, as the use of a generic camera profile is better than not using a profile at all, but there are bound to be subtle differences between camera models, which is why the use of DNG profiles and the ACR/Lightroom route is recommended.

Capture One Pro has a very different interface to Photoshop, Camera Raw and Lightroom. It allows you to modify the colour temperature by neutralising to a reference grey and applying that to a batch of images. Those images can be edited and batch-exported with the characteristics that can be specified in ACR or Lightroom. You can see from the five headings – Basic, File, Adjustments, Metadata and Watermark – that there are plenty of options to use and save in a Process Recipe, so in terms of Standardised Operational Procedures (SOPs), this is a good application to consider.