Digital Records in Orthodontics

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Abstract: **In this electronic age there is a general move towards keeping digital records, and many trades and professions now use digital images exclusively. In this article, the advantages (and occasional disadvantages) of the use of digital photography, digital radiography and the latest development – digital study models – in orthodontics are discussed.**

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Clinical Relevance: **To aid high quality, low cost records to be obtained for all our patients.**

The advantages of digital photography to the dental surgeon are compelling.

- First and foremost is the ability to view the image as soon as it has been taken. This is an invaluable feature, allowing the operator to see whether he/she has captured the image they require immediately. From a teaching point of view this is also an incredibly valuable tool as any mistakes in clinical photography (notably camera positioning and soft-tissue retraction) can be immediately rectified. The trainee photographer receives instant feedback on how well they are doing, which allows rapid improvement in photographic technique.
- Second, the absence of film or processing costs is most welcome. Even using a budget photographic laboratory processing 36 colour prints costs somewhere in the region of £5.00 and 36 slides about £8.50.
- The ability to store records electronically is also useful as, after a number of years, the space needed to store a large volume of photographic records is significant.
- Digital records are very easily retrieved from a computer's hard disk. Duplication is quick and inexpensive and photographs and radiographs of any patient can be transmitted electronically around the world in a matter of seconds, allowing almost instantaneous exchange of useful clinical data.
- The rapid production of digital photographs make them useful as a teaching material or to motivate patients who are losing interest in treatment.
- Digital records also allow complete confidentiality as the number of people who need to be involved in processing and storage of these records is significantly reduced.
- The digital technology allows exposure accuracy to be checked and there is no ageing (colour shifts) of the digital images. Sophisticated camera systems have a built-in white balance, which allows high-quality photographs to be taken in a variety of clinical settings.
- Dust and scratches are now a thing of the past, and previously damaged 35 mm slides can be easily digitized and 'touched up' to remove any flaws. The clinical photograph obtained forms a valuable baseline record of the original malocclusion, detailing the health of the hard and soft tissues at the beginning of treatment. Decalcification is an inevitable result in a small percentage of orthodontic patients, and this can seriously compromise the aesthetics of the patient's dentition. It is very helpful to have a photographic record of patients for whom decalcification had occurred, or who have suffered some trauma to the hard tissues, before treatment: litigation is on the increase and thorough and accurate clinical records are a great help in allowing the clinician to establish the original condition.

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PRODUCING DIGITAL PHOTOGRAPHS

Many trades and professions

Figure 1. *Most trade and professional magazines now use digital photography.*

(including estate agents, advertising agencies, the police and the media) now use digital photography on a routine basis (Figure 1).

The digital 'photograph' is made up using a series of numbers between 0 and 255 for each of red light, green light and blue light. Black is the result of all three colours being set at zero and white results when all three are at their maximum value of 255 (Figure 2). There are therefore 256 levels for each of three colours and if each is set at the same level a shade of grey will result. The resulting spectrum is 16.7 million colours.

The numerical value for each of three colours is stored on the charged-couple device (CCD) housed in the centre of the digital camera. The quality of the digital image is dependent upon how many picture elements (pixels) the CCD contains. The quality of the final image can be enhanced by a system of interpolation (manipulation of the boundaries between the picture elements). Early digital photographs comprised only a few hundred pixels by a few hundred pixels, and were thus of fairly poor quality. The first mega pixel cameras became available in 1999 and currently most mid-range digital cameras will store between one and two mega pixels on the CCD. A number of 'top-end' cameras obtain images in excess of three mega pixels, which, through interpolation, will produce images of more than 6 mega pixels.

The problem with increasing the size of the image is that, whilst the quality improves greatly as more information is stored, the computing power required to manipulate these images also increases, and is not always available. Consequently, downloading and subsequent manipulation of images can be a time-consuming process.

TYPES OF CAMERA

It is essential for the clinician to decide the image output they require and the purpose to which the images are to be put. If only a clinical record is required for use in the event of future litigation, then a medium-quality image with maximum compression is probably sufficient. If, however, the images are to be converted into hard copy (glossy photographs), or used for publication or teaching purposes, a higher quality image is probably required. This decision will affect the choice of camera.

Mid-Range Cameras

The consumer cameras that can be purchased for between £200 and £500 are short on features required for use in a clinical setting:

- the ability to zoom between an image required for extra-oral photographs and that required for intra-oral photographs;
- a macro facility to allow intra-oral close-ups to be taken.

A 35 mm photographic slide is considered to have the equivalent of

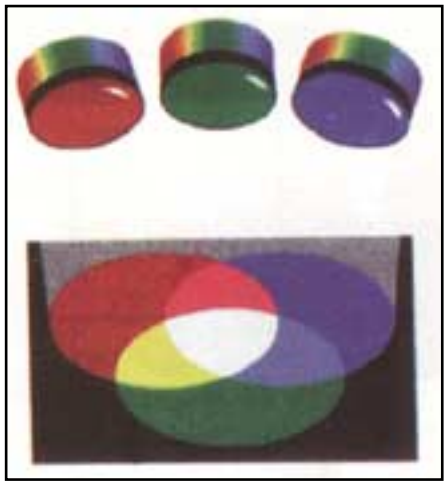

Figure 2. *Digital images are composed of red, green and blue light in various combinations.*

25–30 million pixels. Even the most sophisticated digital cameras are unlikely to be able to store more than 6 million pixels per image, so at very best they are going to provide only a fifth of the information that would be available on a 35 mm slide. It is therefore important to fill the frame with the subject of interest to avoid wasting pixels.

Most mid-range cameras depend upon a point flash system for illuminating the subject. Whilst this is fine for extra-oral pictures, it is problematic when taking intra-oral shots. As the camera must be quite close to the subject, a point flash will tend to produce shadowing effects on the standard intra-oral and occlusal views. One way round the problem with the occlusal view is to take the picture from much further away – but this

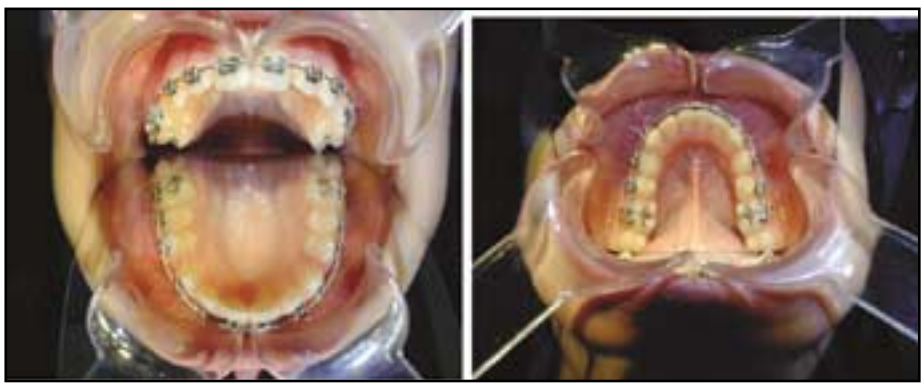

Figure 3. *For point flash to illuminate subject adequately a significant number of pixels must be 'wasted'.*

Figure 4. *The Fuji Finepix S1 Pro camera with Nikon flash and lens.*

means that only 20% of the CCD contains information on the area of interest, and therefore a large pixel count is essential (Figure 3). Various camera systems have been developed to avoid the problems with the point flash: one system provides a diffuser to be placed in front of the point flash to reduce the harshness of the flash light, but this is not really successful in producing perfect illumination; another system attempts to use mirrors to reflect light from the point flash to illuminate the buccal sulcus, but again this system is less than ideal.

Over the last 20 years, there has been a great deal of interest in clinical dental photography. One thing that has been consistently demonstrated is that, for high-quality photographs, SLR systems, which allow viewing of the subject through the lens, are essential. In addition, through-the-lens metering combined with multi-flashes produces the best quality intra-oral photograph. These features are not usually found on mid-range cameras.

Another problem with the mid-range systems is that the auto-focus systems do not work well intra-orally. It can be very frustrating, when the retractors are all in place and the patient has been positioned specifically to take a high-quality photograph, for the auto-focus to 'hunt' in and out to try to find an area on which it can focus. Some of the mid-range cameras are provided with a rapid manual focus system whereby, at the push of a button, a 12-inch focal length can be fixed, but these systems have limited success.

Top-End Cameras

The camera system that we finally settled on is the Fuji Finepix S1 Pro, an SLR system using a Nikon 105 mm/2.8 macro lens, an SB29 Nikon speed light and a Nikon body built to a very high specification (Figure 4). Perfect illumination of the photographs is provided by the multi-flash, which works with a through-the-lens metering system. Aperture priority can be selected and the Nikon SB29 speed light is sufficiently powerful to allow perfect pictures to be taken at a very small aperture of F32. This ensures maximum depth of field, thus giving a high-quality result. All pictures are taken on manual focus and (provided the patient is well illuminated with the dental light) moving backwards and forwards can allow very easy focusing of the subject.

A variety of settings are available for recording the image, from a 'basic' setting which maximally compresses the images using a JPEG format, to a 'fine' setting whereby the images are stored as TIFF files and are totally uncompressed. The quality required for routine clinical purposes is on the lowest of the three pixel settings with maximum compression, which allows 330 images to be stored on a 64 megabyte card. Extra-oral and intra-oral photographs can also be taken with the same lens and the only adjustment (in addition to the focal length) that needs to be made is that the aperture should be opened up to F11 and one of the flash bulbs switched off for the profile and three-quarter shots. This allows the patient's shadow to be thrown behind the profile, thus producing a high-quality image (Figure 5).

Figure 5. *Profile shots can be greatly improved when shadow is thrown behind the subject.*

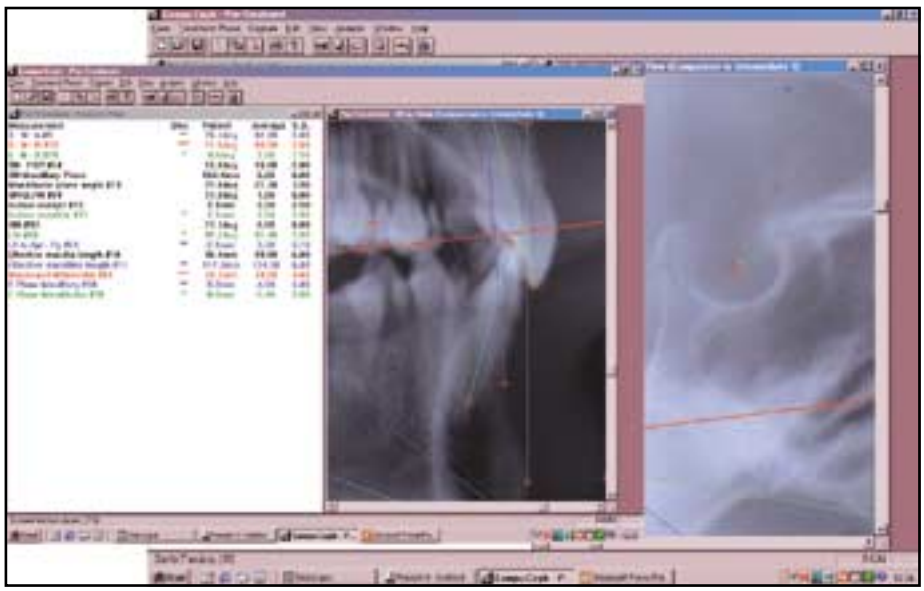

Figure 6. *Adjustment of cephalometric points is possible using on-screen digitization software.*

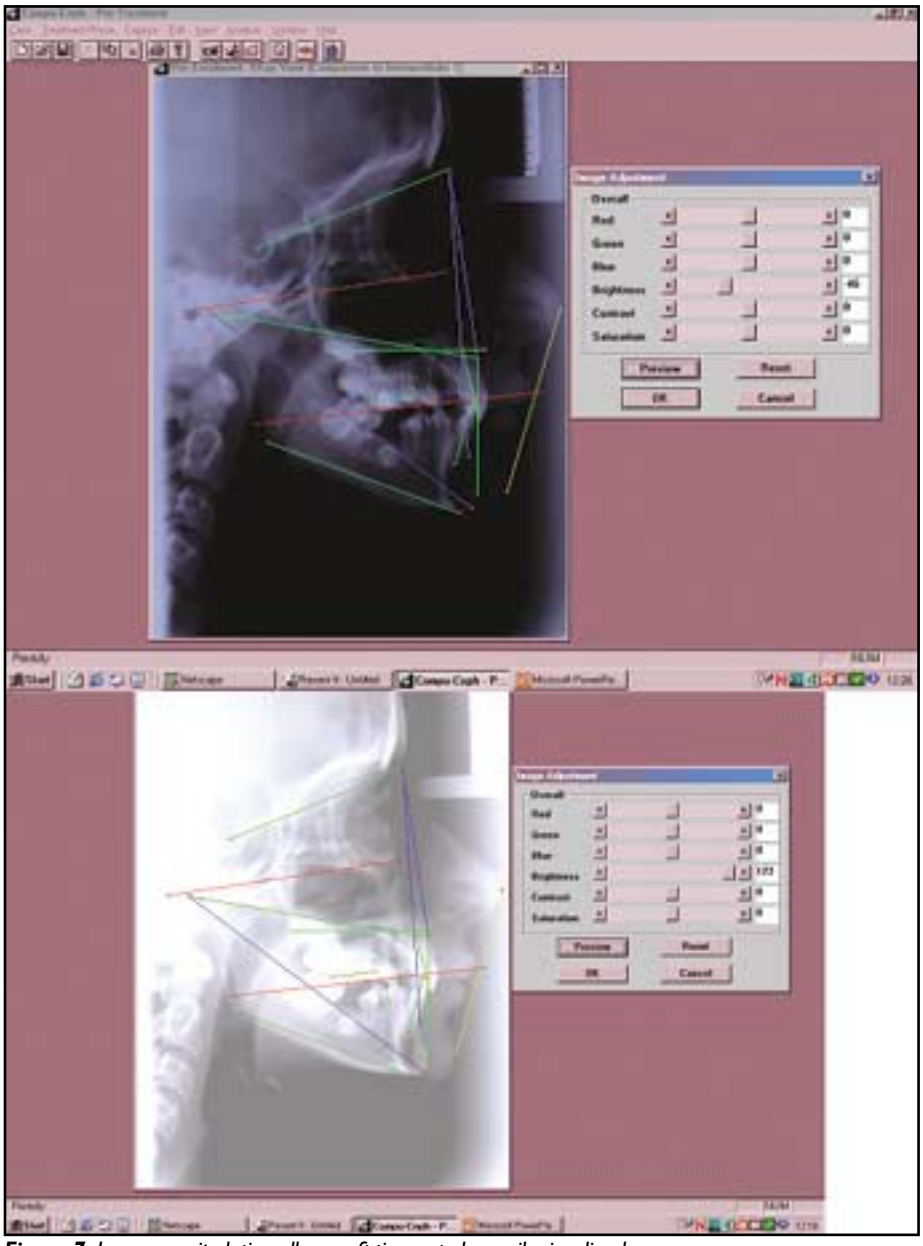

Figure 7. *Image manipulation allows soft tissues to be easily visualized.*

The system has been in use by the postgraduates at Manchester University for the last 9 months without any real problems. The major advantage of the system is that the account for the processing of clinical slides has disappeared. Within a 3-year course both digital cameras will be paid for by these savings, and from that point onwards digital photography will be free. The initial worries about digital photography (that the quality of the images were nowhere near comparable to the 35 mm slides, that the point flash system commonly used in most digital cameras was unsatisfactory for intra-oral photography because of the unacceptable shadowing which occurred on all the images, and that the point flash systems employed were not sufficiently powerful to allow a very small aperture to be used for the intra-oral shots) have been overcome with the Fuji S1 probe.

DIGITAL RADIOGRAPHY

A recent survey in the USA shows that there is a slow but steady move towards digital radiography. Digital OPG and Ceph machines with an internal CCD have been available since 1996, and an OPG/Ceph machine with photo-stimulatable phosphor (PSP) plates has been available since 1998. The former system records an image on the CCD which is immediately downloadable as a digital image onto a computer screen. The latter relies upon intensifying screens that glow when hit by X-radiation and temporary storage of the image by the PSP. The plate is then passed through a reader, which converts it to a video image that can be sent to a computer and displayed on a monitor; the plate is then wiped and is ready for re-use. A third way of obtaining digital radiographic images is by scanning conventional radiographs in a scanner that has a transparency adapter.

Generally, digital images are now of more than adequate quality and are certainly equal to conventionally obtained radiographs. The digital images can be enhanced by special software and the images are therefore slightly more forgiving of poor technique.

Using the CCD system of digital radiography, the image is instantly obtained, thus saving the clinician time. It has been claimed that the radiation dosage reduces to about 10%, although this claim has not been substantiated with extra-oral films, and the actual reduction in radiation is probably more like 50%. The quality of the radiographs is more than acceptable and there are no chemicals or film to buy. It is possible to digitize on screen and therefore the system is considered to be both operator and patient friendly. There is instant access via the computer to archives of patients' radiographs.

Clinicians who are intending to buy a new OPT/Ceph machine should give serious consideration to a digital machine (either with a CCD or the PSP system), or at least buy a machine that will be upgradeable to digital. The authors consider that digital radiographs will become the norm within the next 10 years. However, any practitioners who have an old X-ray

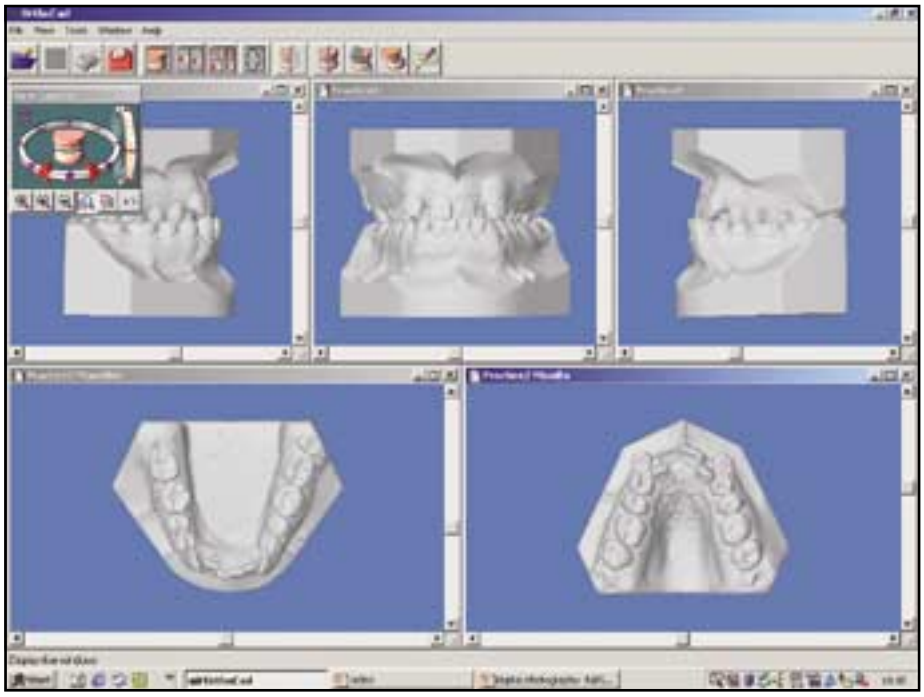

Figure 8. *Digital study models can be viewed from any aspect.*

machine that is still producing acceptable radiographs may be best advised to wait for the time being as the prices of digital machines are dropping almost as quickly as the quality is improving.

When considering software for managing both digital photos and digital radiographs it is essential to ensure that the system is well developed, and that all the bugs have been identified and corrected. Most reputable software companies will allow an evaluation copy to be experimented with. It is advisable to evaluate several software systems in order to find one to suit your particular needs.

ON-SCREEN DIGITIZING

A number of software packages are available for on-screen digitization of images and the reliability of digital images has been investigated by a number of workers.[1–3]

The advantages of digitizing on screen are:

- There is no need to buy expensive (and sometimes bulky) digitizing tablets with associated hardware. On-screen digitizing is carried out directly on the computer screen using the mouse, and technology with which the clinician should be familiar (Figure 6).
- The brightness, contrast and saturation can be altered on the radiograph, which can make identification of hard and soft tissue somewhat easier (Figure 7).
- With some packages (e.g. American Orthodontics, Compuceph) it is possible to review the placement of cephalometric points. If the cephalometric points have not been placed in a perfect position they can be moved to the correct position and, at the same time, the analysis will be adjusted accordingly. This is an invaluable teaching tool, which can aid junior and ancillary staff in their cephalometric digitization.

DIGITAL STUDY MODELS

Every orthodontist in the land has a major storage problem with study models. It is a legal requirement to keep these records until 7 years after the end of treatment or until the patient is 25, whichever is the longest. A great deal of time and effort is spent filing, boxing, packing and generally looking after these study models. A company called Orthocad is currently offering to provide digital models, which holds the potential to revolutionize retrieval, analysis and storage of study models (Figure 8). Their website can be reached at

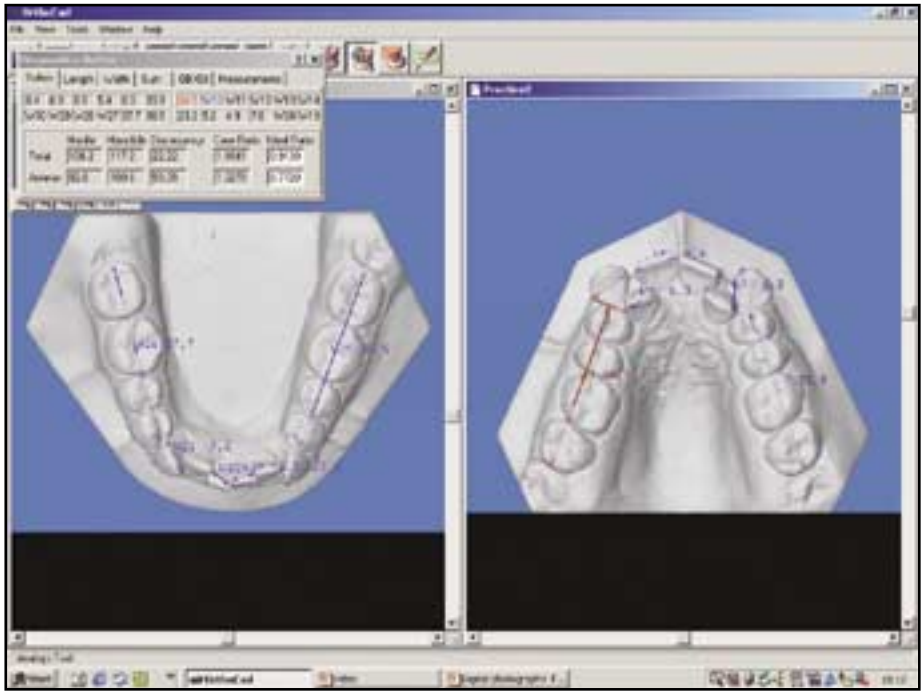

Figure 9. *Space analysis can be carried out on digital study models.*

www.orthocad.com. Alginate impressions, plus a wax bite, should be sent to the company in America, who will then send the digital study models back to the clinician's computer within 7–10 days.

Digital study models can be viewed from any angle, turned through 360° in all planes of space and even opened to allow upper and lower models to be viewed separately. Measurements can be carried out to allow space analyses to be conducted (Figure 9). The digital study models can be turned back into a genuine set of study models. This is somewhat expensive, running at $400–$600 per case; however, the cost is expected to reduce significantly within the next 2–3 years, and the need to convert the digital study models back into a genuine set of study models may occur only rarely, perhaps in litigation cases.

SUMMARY

Digital technology has revolutionized the storage and handling of orthodontic records. Digital photographs give the unique opportunity to learn to produce very high-quality extra-oral and intra-oral photographs. The digital technology also allows an enormous amount of leeway in technique as, with the current software available, manipulation of the images is very easy. Digital radiographs are instantly viewable and, combined with on-screen digitization, make the entire process much less tedious. Digital study models are undoubtedly going to become very useful in the future.

References

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3. Geelen W, Wenzel A, Gotfredsen E, Kruger M, Hansson LG. Reproducibility of cephalometric landmarks on conventional film, hardcopy, and monitor-displayed images obtained by the storage phosphor technique. *Eur J Orthod* 1998; **20:** 331–340.

ABSTRACT

CARIES STILL NUMBER ONE

The Reasons for the Extraction of Various Tooth Types in Scotland: A 15-year Follow-up. L.K. McCaul, W.M.M. Jenkins and E.J. Kay. *Journal of Dentistry* 2001; **29:** 401–407.

This study was a follow-up of a similar study performed previously in 1984 to determine the reasons for tooth extraction in Scotland. A questionnaire-based study was used and circulated to 20% of Scottish GDPs to be completed over the course of one week. In an admiral response rate of 83%, the authors reported that 25% fewer teeth were extracted per patient than in 1984. The most frequently extracted teeth were upper premolars followed by upper third molars, then lower first and second molars. Caries was the main cause for extraction of teeth, followed by periodontal disease, then orthodontics. Indeed, in the under 21 age group of patients, premolars were more frequently extracted than molars, compared to 1984; this was accounted for by the increase in orthodontic treatment.

The results of the study demonstrated a changing pattern of dental status in Scottish patients, echoing the results of the 1998 Adult Dental Health Survey.

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ERRATUM

In the article by G.J.P.Fleming, F.J.T.Burke, D.J.Watson and F.J.Owen: **Materials for Restoration of Primary Teeth: 1. Conventional Materials and Early Glass Ionomers** (*Dent Update* 2001; **28:** 486–491), Figure 1 should be as follows:

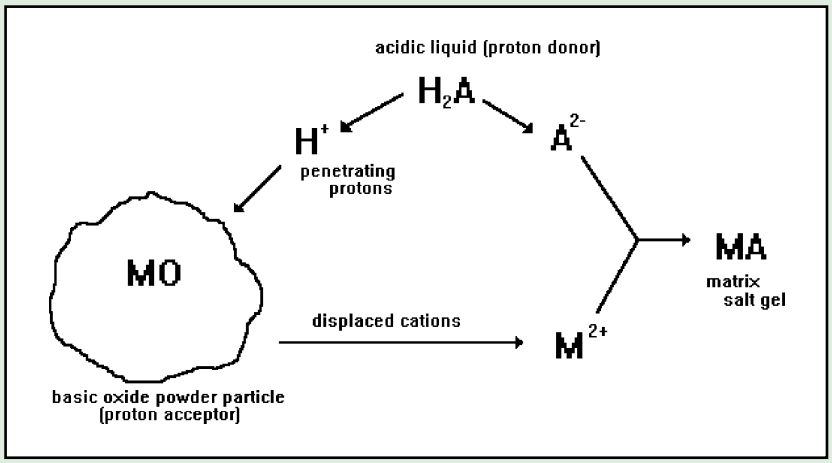

Figure 1. *The setting reaction in acid-base dental cement: hydrogen ions from the liquid penetrate into the powder particles, liberating metal ions that migrate into the liquid and combine with the anion to form the salt-like gel matrix.*