For some time, we have been benefiting from IPS e.max® CAD-on/Veneering Solutions (Ivoclar Vivadent), a working technique that combines lithium disilicate (LS2) and zirconium dioxide (ZrO2). In addition to IPS e.max ZirCAD and IPS e.max CAD blocks (Ivoclar Vivadent), the technique includes the use of a high-frequency vibrating device (Ivomix, Ivoclar Vivadent) and a special thixotropic fusion glass-ceramic to join both of the ceramic structures. In this case report, we will demonstrate how to implement the technique step by step in order to achieve natural-looking and functional restorative results.

In our case, the patient visited the dentist because she was unhappy about her maxillary anterior restoration. The ceramic material had flaked off at several sites and the function of the metal–ceramic bridge was impaired. Consequently, she wanted to have it replaced (Fig. 1).

During the try-in, the contour of the artificial gingiva was determined and shaped (Fig. 1). Based on the wax-up, the technician created a temporary that was allowed to heal for a sufficient period (Fig. 2). Meanwhile, the technician fabricated a diagnostic temporary for evaluation of the aesthetic and functional parameters. In order to achieve a harmonious smile, the incisal edges of the anterior teeth had to be lengthened considerably (Figs. 3a & b).

A detailed examination of the clinical situation established that, owing to severe bone atrophy, teeth #11 and #21 were not suitable for anchoring a new dental prosthesis to them and that they would have to be extracted. Since the patient was unwilling to undergo augmentative procedures, placing an implant-retained prosthesis was not an option. Instead, we decided to install a fixed bridge that would be anchored to abutment teeth #14 and #12 on one side and to teeth #24 and #22 on the other side. The area surrounding teeth #11 and #21 would have to be reconstructed with artificial gingiva.

**Trends & Applications**

**Massimiliano Pisa**
Italy

For some time, we have been benefiting from IPS e.max® CAD-on/Veneering Solutions (Ivoclar Vivadent), a working technique that combines lithium disilicate (LS2) and zirconium dioxide (ZrO2). In addition to IPS e.max ZirCAD and IPS e.max CAD blocks (Ivoclar Vivadent), the technique includes the use of a high-frequency vibrating device (Ivomix, Ivoclar Vivadent) and a special thixotropic fusion glass-ceramic to join both of the ceramic structures. In this case report, we will demonstrate how to implement the technique step by step in order to achieve natural-looking and functional restorative results.
functional requirements of the patient. The situation achieved with this rather gradual approach was used as a reference in the subsequent fabrication of the final restoration (Fig. 5).

It was then time to select the materials and manufacturing method that would allow the data gathered in the previous processes to be converted into a high-strength aesthetic restoration. We opted for the IPS e.max CAD-on technique/IPS e.max CAD Veneering Solutions, as this method allowed for accurate reproduction of the diagnostic wax-up. Dedicated software divides the data into two sets for the production of the ZrO₂ framework and the LS veneering structure. The model and the wax-up were both digitalised and imported into the program (Figs. 6a & b).

The primary structure (framework) was created using ZrO₂ according to the CAD/CAM technique. Its accuracy of fit was checked on the model, and then the framework was sent to the practice for try-in (Figs. 7–9). The framework showed an excellent fit and did not require any reworking (Fig. 10).

Based on the data, the veneers were milled from IPS e.max CAD. This secondary structure was easy to adapt to the framework (Fig. 11). Still in their intermediate (pre-crystalline) state, the LS veneers were adjusted to match the pre-existing morphological characteristics. A base for veneering the gingival parts was also created. Contouring the artificial gingiva with composite material by a dentist would happen at a later stage.

We were now ready for the final stage. After checking the functional and morphological parameters, we joined the ZrO₂ framework and LS veneer with the IPS e.max CAD Crystall./Connect fusion glass-ceramic and an Ivomix mixing device (Figs. 12a & b). Crystallisation or fusion firing was conducted in a Programat furnace using a dedicated firing program. Afterwards, the restoration was customised to match the specific characteristics of the patient’s dentition and subjected to a characterisation/glaze firing process (Figs. 13 & 14).

Completing the restoration

After the try-in, the restoration was returned to the laboratory to add some final touches. A few characterisations were applied according to the given requirements. Those areas of the framework to be veneered with composite were etched to prepare them for the application of the composite material. In the practice, the gingival parts were reproduced using gingiva-coloured composite with the temporary as a guide (Fig. 11). A natural-looking gingiva shield was achieved by applying the material in small quantities in several steps. Finally, the ceramic bridge was seated using conventional procedures. The result was a restoration that blended in so well that it could hardly be distinguished from the surrounding natural dentition (Figs. 16 & 17).

Chipping of the veneering ceramic on ZrO₂ frameworks can often be traced back to a failure to observe the material-specific technical requirements. By using the CAD-on technique described in this report, the risk of failure can be minimised for these kinds of restorations, because the strength of the veneering ceramic used with this technique is four to five times higher than that of conventional veneering ceramics.

The high strength of the ceramic has been confirmed in a study that compared bridges manufactured using the CAD-on technique with ZrO₂ bridges veneered using an individual layering technique. The results of the study showed that the strength of the CAD-on bridges was twice as high (2.188 ± 0.505 N) as the strength of conventionally veneered bridges.

In this case, accurate diagnostic measurements taken at the preservative stage, in-depth knowledge of the materials involved in the treatment process, and excellent collaboration led to a highly aesthetic result without the need for surgical intervention. The procedure ideally combines two outstanding materials and has proven to be both reliable and cost-effective.

Acknowledgement

This case was conducted in collaboration with dental technician Paolo Vigani and Dr. Leonardo Barchioni from Florence. I would like to thank them both for their support.

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Since its commercial introduction into dentistry in 2001, cone beam computed tomography (CBCT) has been rapidly evolving into a new standard of care in maxillofacial imaging. In just over a decade, CBCT has exploded onto the dental landscape and permitted dental professionals a degree of three-dimensional (3-D) anatomic truth in maxillofacial imaging previously unavailable and unattainable.

Like many other new technologies, which have progressed from the extraordinary to the ordinary and thus gained acceptance by professionals and patients, CBCT has advanced from exceptional use to almost commonplace use in dentistry as cost decreases, access to the technology increases, and potential adverse patient interaction (i.e., radiation exposure) is attenuated. Today, CBCT is seen by many in dentistry as the standard operating procedure for many dental procedures, orthodontic, endodontic, or endodontic cases.

The advancement of CBCT in dentistry has caught the attention of manufacturers of radiographic equipment. In 2001, only one company sold a CBCT system. In 2014 there are at least 20 companies selling CBCT machines and technology. Henry Schein, a leading distributor of dental equipment, has seen CBCT sales expand from 5 per cent of their digital imaging sales to almost 50 per cent of digital imaging sales in the last five years.

CBCT has also been recognised by general dentists and specialists as a means by which they can better understand and distinguish their practices as being on the vanguard of technology in patient care. Today’s patients expect their dentist and physicians to be contemporary with technology and services. CBCT provides the doctor with a technology, which not only has significant advantages in treating patients but also has a noteworthy “wow” factor as the 3-D images are seen on a large screen in “real time” for the doctor and patient to view.

CBCT, like plain film radiographic studies, may be considered a revenue generator for a practice. The more a CBCT machine is utilised, the more revenue it will generate. Additionally, the owner may allow others in the profession to utilise the machine for a fee, thereby reducing his overall cost of operation.

Standard of care is a legal not a medical or dental concept. Standards of care are continually evolving as methods and techniques in patient care improve. An appropriate definition for standard of care may include such language as: the dentist is under duty to use that degree of skill and care which is expected of a reasonably competent and prudent dentist under the same or similar circumstances. Standards of care may be local, regional or national.

Standard of care influences

The influence of an emerging technology, like CBCT, into a new standard of care involves many criteria. These criteria include:

- CBCT technology is used by a group of cases in which CBCT is used properly for evidence in treatment planning or defending good practice.
- A radiographic study is the standard of care in each factor. For example, if the radiographic study is the standard of care in each factor, the patient will be able to review the radiographic study and decide whether the radiographic study is the standard of care in each factor. If the patient decides that the radiographic study is not the standard of care in each factor, then the radiographic study is not the standard of care in each factor.
- The patient’s decision is the standard of care in each factor. The patient’s decision is the standard of care in each factor.
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In Frey, the court opined: “Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the hypothesis is strong enough to be used as a basis for a plausible scientific claim.” CBCT is such a technology. CBCT technology has been tested and proven over many years of application in the medical and dental arena. The Hounsfield unit is the widely recognised standard quantitative scale for describing radiographic density and provides doctors with a known standard and error rate in computed tomography. The widespread acceptance of CBCT by the medical and dental community is demonstrated by the ever-increasing presence in dental and medical practices.
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Evaluation of Table 1 data clearly shows a significant presence in the literature of articles pertaining to the use of CBCT in various disciplines in dentistry. The vast majority of literature discovered pertains to addressing the use of CBCT in treatment planning and diagnosis of patients in implant therapy, oral and maxillofacial surgery, orthodontics, and endodontics. Articles on new applications of CBCT technology to patient care were also prevalent in the sample. Some articles addressed the risk and benefits of CBCT but none denounced CBCT as harmful to the patient or insignificant in treatment planning and diagnosis. Two similar PubMed reviews of the literature on CBCT were performed by authors Alamri et al (Applications of CBCT in dental practice: A review of the literature, Gen Dent 2012; 60(5): 390–400) and De Vos et al (Cone-beam computerized tomography (CBCT) imaging of the oral and maxillofacial region: Systematic review of the literature. Int J Oral Maxillofac Surg 2009;38: 609–625).

Both of these exhaustive articles demonstrate the plethora of literature addressing CBCT and its application in the many disciplines of dentistry. Article then lists nine professional guidelines. For a technology such as CBCT to become a standard of care in dentistry, guidelines for its use and application in patient care must be established by the organisational bodies of those disciplines that independently employ the technology to treat patients. In dentistry, the dental practitioners most involved in the use and application of CBCT in patient care include general dentists, oral and maxillofacial surgeons, endodontists, oral and maxillofacial radiologists, orthodontists, and periodontists.

The American Dental Association has over 180,000 licensed dentists representing approximately 75 per cent of dentists in the USA. The American Dental Association published an advisory statement article in its principal journal, The Journal of the American Dental Association, in August 2012. The article discusses the many positive aspects of CBCT, but stops short of calling CBCT a new standard of care. Rather, the ADA encourages the dentist to use CBCT “selectively, as an adjunct to conventional radiography”. The ADA further recognises the value and presence of CBCT by including CBCT-related courses at its annual meetings and continuing education programmes, 87 per cent of programme directors acknowledged the use of CBCT in patient care as far back as 2011. The AAOMS has worked with the IAC to develop guidelines and accreditation criteria for 3-D CBCT imaging. In a recent survey of OMFS residency programmes, 87 per cent of programme directors acknowledged the use of CBCT in patient care by their residents.

The American Association of Oral and Maxillofacial Surgeons (AAOMS) has over 9,000 members representing approximately 95 per cent of oral and maxillofacial surgeons practising in the US. Literature addressing the application of CBCT in oral and maxillofacial surgery has been around since 2007. The AAOMS has offered continuing education in the use and application of CBCT for patient care as far back as 2011. The AAOMS has worked with the IAC to develop guidelines and accreditation criteria for 3-D CBCT imaging. In a recent survey of OMS residency programmes, 87 per cent of programme directors acknowledged the use of CBCT in patient care by their residents.
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Oral Implantologists (ICOI), the CBCT in patient care. CBCT in periodontics first appeared in
periodontics and orthodontics programmes in the US incorporate CBCT in their dental implant education curriculum. Many professional organisations in dentistry for general dentists and specialists have weighed in on providing recommendations, guidelines, and a position paper. While these guidelines are beneficial in establishing a society or specialty's position on CBCT, they are not mandatory. Recommendations, guidelines, CE programmes, and position papers are used by organisations to influence the practice of their discipline. As the practice of dental care becomes more complex, including many factors including, but not limited to, expert testimony, literature support, professional guidelines, cost of the technology, and reimbursement by third party payers; the recommendations, guidelines, and position papers are necessary to facilitate the evolution of CBCT into a standard of care. Thus, in 2014 many professional organisations that comprise dentistry may not formally declare CBCT is the standard of care for every patient, but these organisations do recognise the influence CBCT has on the practice of dentistry.

Educational Institutional Participation

For a technology to be considered a standard of care, those in the professions who might educate and train in its application in patient care, need to incorporate CBCT. Eighty-seven (84 per cent) incorporate CBCT education in their pre-doctoral curriculum. In a survey performed by the author and others 202 general practice residents (GPR) and advanced education in general dentistry (AEGD) programmes were surveyed regarding use of CBCT by their residents. Eighty-two programme directors responded to the survey. (88 per cent) of programme directors (PDs) responded affirmatively when asked if CBCT is used in patient care by their residents. The author also surveyed 302 PDs in oral and maxillofacial surgery (OMS) and oral and maxillofacial pathology (OMFP) programmes in the US. Fifty-four PDs responded. Of the 54 PDs responding, 47 (87 per cent) responded affirmatively when asked if CBCT is used in patient care by their residents. In a phone survey of endodontic residencies, 44 of 47 PDs indicated their residency uses CBCT in patient care. All seven ADA-approved oral and maxillofacial radiology programmes use CBCT in patient care. Additionally, all 92 crop directors indicated that their residency employ CBCT technology in imaging; 63 (69 per cent) of programmes use CBCT in imaging; 85 per cent of US-based orthodontic programmes use CBCT in imaging. The lion's share of research in applying CBCT technology to dentistry. The vast majority of post-doctoral residencies involved in dental implant patient care and all primary dental training courses in the US incorporate CBCT in their dental implant education curriculum.

The tremendous value of anatomic truth in complex orthodontic or surgical planning with cleft lip and palate, impacted teeth, and maxillofacial deformities is widely recognised and discussed in the literature. Recent clinical and radiation surveying literature syllabus shows CBCT is a prominent topic for today's oral and maxillofacial radiologist and providers. CBCT may soon represent a new standard of care for general dentistry and its effect on the paediatric population will be significant. However, should CBCT become a standard of care; cost, availability, and recognition must work their way into the mainstream culture of dentistry. The increasing acceptance will increase, facilitating the incorporation of CBCT into the mainstream culture of dentistry. The increasing acceptance of CBCT technology will not singularly make it a standard of care, but will serve to increase patient awareness of the technology, which in turn will influence what the public perceives as a standard of care.

The insurance industry

Reimbursement from major insurance carriers for CBCT in general dentistry is traditionally the last to embrace new technology. CBCT is particularly well suited for dental care. The American Association of Implantologists (ICOI), the CBCT in the dental culture

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Oral Implantologists (ICOI), the CBCT in patient care. CBCT may provide dose savings over conventional radiographs and allow the maxillofacial surgeon to see and plan for: impacted teeth, and maxillofacial craniofacial anomalies, TAD placement, TMJ assessment, and position papers are used by organisations to influence the practice of their discipline. As the practice of dental care becomes more complex, including many factors including, but not limited to, expert testimony, literature support, professional guidelines, cost of the technology, and reimbursement by third party payers; the recommendations, guidelines, and position papers are necessary to facilitate the evolution of CBCT into a standard of care. Thus, in 2014 many professional organisations that comprise dentistry may not formally declare CBCT is the standard of care for every patient, but these organisations do recognise the influence CBCT has on the practice of dentistry.

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“Photo-functionalisation is effective on any implant surface type”

An interview with Dr Takahiro Ogawa, US

A professor in the Division of Advanced Prosthodontics at the University of California, Los Angeles School of Dentistry in the US, Dr Takahiro Ogawa is one of the main advocates worldwide for photo-energy-mediated activation of implant materials, a process also known as photo-functionalisation. Dental Tribune Asia Pacific recently had the opportunity to talk with him about the benefits and prospects of this innovation.

Dental Tribune Asia Pacific: Photo-functionalisation is achieved by exposing titanium surfaces to ultraviolet light. Would you describe in more detail the mechanical or chemical processes that take place during the process?

Dr Takahiro Ogawa: Photo-functionalisation is a 12-minute conditioning of dental implants in the device immediately prior to implant placement. The reason for this process is that titanium ages with time, and this particularly affects its ability to integrate with bone.

The photo-energy activation device boasts an optimised combination of ultraviolet lights that effectively remove hydrocarbon from the implant surface, transforming the surface from hydrophobic (water-repelling) to hydrophilic (water-friendly). This change in properties, together with the clean titanium surface, attracts more osteogenic cells. Photo-functionalised titanium surfaces are electrostatically positive and further enhance cell attraction because cells are electro-negative.

All this is intended to make osseointegration of dental implants much better and faster. The ageing process of implants degrades hydrophilicity. Can the features of an aged implant surface be fully restored by photo-functionalisation, and does the technology have any limits?

Not at all. A series of studies have indicated that photo-functionalisation is effective on any implant surface type tested whether acid-etched, dual acid-etched, oxidised, sand-blasted, nano-featured or machined surfaces. While photo-functionalisation can restore implant properties to a degree similar to when it was manufactured, the revitalised implant surfaces degrade time-dependently in the same way as those of regular implants. Therefore, dental implants undergoing treatment with the device need to be placed immediately.

Has the technique been tested in in vivo studies and, if so, what results have you found so far?

According to a number of preclinical studies, the strength of osseointegration can be increased three times by photo-functionalisation at the early healing stage. Photo-functionalisation makes implant and abutment surfaces bacteria-phobic.

The bone-implant contact of photofunctionalised implants reached 98.2 per cent, compared with 50–55 per cent achieved with the control implants. Moreover, it has been found that photo-functionalisation increases the quality of marginal bone formation, as well as improves the outcome of guided bone regeneration, when applied to titanium mesh. Studies indicate that there are not only short-term benefits of photo-functionalisation. Reliability and predictability in function and aesthetics are expected to increase with time, providing clinicians with a new strategy for a better long-term prognosis for dental implants and reducing the risk of peri-implantitis.

You say that photo-functionalisation could become a standard procedure for dental implant therapy. When will that happen, in your opinion?

Dental Tribune Asia Pacific: Photo-functionalisation could become a standard procedure for dental implant therapy. In Europe, premarketing of the photo-functionalisation device has recently started. I believe that other regions will catch up shortly and make this technology a global standard in implant dentistry.

A number of projects are also underway utilising photo-functionalisation in the field of general bone engineering and orthopaedic implants and reconstruction.

Thank you very much for the interview.
Forensic odontology—Broader than just identification

Dr Richard Bassed
Australia

Nowadays, most people will associate forensic dentistry primarily with identification and bite mark analysis. These areas do indeed form the majority of an odontologist’s workload. There are, however, other aspects of the discipline that are just as important but perhaps less well known. These include cranio-facial trauma analysis, age estimation for both living and deceased individuals, dental manifestations of child abuse, dental malpractice investigations, as well as dental insurance fraud.

Forensic odontology is an integral part of the medico-legal process. With this comes a responsibility borne by forensic odontology practitioners for the requisite education, qualifications and ongoing training. Courts and legal institutions now require that we have evidence-based research upon which we can rest our findings and conclusions. In addition to knowledge of the law, we have to have knowledge of human anatomy and its relationship to injury patterns and interpretation. Knowledge of bite mark patterns due to assault, trauma and sexual abuse, as well as child abuse injury manifestations, is also required, as is knowledge of assessment techniques used when the age of an individual is unknown. Finally, there is a need to have knowledge of human identification methods, principles and practices, as well as mass disaster identification procedures and protocols, and the ethical issues involved in the examination and management of dead bodies, and to have an understanding of human rights issues involved in war crimes investigations.

All of these require thorough knowledge of cranio-facial anatomy, dental anatomy, dental and skeletal development, injury interpretation and medico-legal report writing. It is also important to have a good understanding of the law relating to the practice of dentistry, the coronial system, and the criminal justice system. As the majority of the forensic odontology caseload concerns the identification of unknown deceased individuals, most discussion in this article will concentrate on this.

Honouring the dead is a fundamental precept in all societies. The extent of this communal attention to the deceased varies across the world, but in essence everyone hopes that their or her remains will be treated with respect after death. This respect for the dead includes, for many societies, robust identification of the deceased so that relatives and friends are able to treat the remains with appropriate ceremony and are able to visit the resting place of the deceased whenever they wish. So important is the perception of personal identification in almost all societies that authorities will go to extraordinary lengths to ensure that deceased individuals are not interred in unmarked graves, or cremated without a name.

To be buried anonymously goes against all of our religious, cultural and ethical belief systems, and implies that a life unremembered and unmourned was really a life without consequence. William Gladstone, Prime Minister of Britain in the mid-1800s, encapsulated this sentiment better than most when he said, “Show me the manner in which a nation cares for its dead and I will measure with mathematical exactness the tender mercies of its people, their loyalty to high ideals, and their regard for the laws of the land.”

Hal Hallenstein, the Victorian State Coroner from 1986 to 1994, also had firm views concerning the importance of human identification, articulated in the following quotation: “It is a hallmark of our civilisation that we regard it as an affront, an indignity, an abrogation of our responsibilities, that a person could live amongst us, die and be buried without a name.” In fact, the importance of identification of the deceased is enshrined in the Victorian Coroners Act 2008 (section 67), which states “A coroner investigating a death must find, if possible, the identity of the deceased, the cause of death, and the circumstances in which the death occurred.”

Of all the scientific methods, molecular biology is the only method that can mathematically quantify the degree of certainty for a particular match, with the other methods (including odontology) being somewhat dependent on more subjective method-ology and expert opinion. This reliance on even a small level of subjectivity can raise issues in courts when lay people do not have a deep understanding of the methods employed in an expert’s conclusion.

Confusion can arise from the fact that there is often no unanimous indication regarding which and how many characteristics are necessary in order to achieve a positive identification. The occurrence of several concomitant features excludes identity; the occurrence of several concordant features commonly observed within the population does not allow a final judgment on identification, whereas even a few features rarely observed can lead to a positive match. An example of this is a case in which the written dental chart describes amalgam restorations in each first molar.

If the same is found in the deceased, is this sufficient evidence to confirm identity? Definitely not, as many people share this restoration pattern. If, however, we also have ante-mortem radiographs of those restorations displaying the exact shape, size and location within each tooth, and these compare favourably with the post-mortem radiographs, then few would argue that a positive match cannot be confirmed. There is, however, still no way to quantify this match, to put a probability ratio or a percentage certainty to it.

It may be necessary in some cases to compare all of the teeth in a mouth in order to arrive at a match. In other cases, a single tooth with an unusual or complex restoration may be sufficient. It has long been the wish of identification experts to be able to quantify such matches, but no reliable method has yet been developed.
When it is determined that visceral recognition is not an option, usually because of trauma, incineration, decomposition, or multiple deaths resulting from a single incident, then forensic practitioners are able to rely on more scientific means to determine identity. The common methods employed include molecular biology, medical records, dental fingerprints, and dental record comparison.

DNA profiles are encrypted sets of numbers that reflect a person's DNA make-up, which can also be used as the person's identifier. Although 99.9 per cent of human DNA sequences are the same in every person, enough of the DNA is different to distinguish one individual from another, unless they are monozygotic twins. DNA profiling using identification using fingerprints (friction ridges) relies on an examination of ante-mortem prints already on file with authorities (exemplars), or more commonly, comparison with latent prints retrieved from an object the subject of the examination was known to have touched. Finger-print identification involves an expert, or an expert computer system operating under threshold scoring rules, determining whether two friction ridge impressions are likely to have originated from the same finger or palm (or toe or sole). The validity of forensic fingerprint evidence has been challenged by academicians, judges and the media. While fingerprint identification was an improvement on earlier anthropometric systems, the subjective nature of matching (especially when incomplete latent prints are used), despite a very low error rate, has introduced an element of controversy.

Medical record comparison can be used for identification purposes when there is sufficient ante-mortem evidence of unique medical intervention or disease. Examples include the discovery of medical prostheses, such as pacemakers and prosthetic hips, which will have engraved on them serial numbers, which can also be challenging. In order to reach conclusions to these difficult identification puzzles, the forensic dentist not only needs a solid grounding in all of the techniques available, but also requires a level of experience and, in the case of teeth, a degree of mentoring.

Dental identification is not only achieved using comparison of restorations; other features of the teeth and maxillofacial skeleton may also be employed. Root morphology, sinus configuration, unusual crown shape, and pulp chamber morphology are all factors that can be considered in the absence of restorations, as long as there are high-quality ante-mortem images with which to make a comparison. Study models, sport mouth guards, partial dentures, orthodontic appliances and photographs of the dentition are all useful aids for a forensic odontologist and are employed with varying degrees of certainty, depending on the circumstances of the case.

Personal identification via dental record comparison is similar to fingerprint analysis in that there is a high level of doubt, an element of subjectivity involved in the matching process. Where dental fingerprints differ, and is perhaps easier to comprehend for lay people, is in the nature of the comparison being made. With dental evidence, matches are commonly assessed by comparing ante-mortem scans and post-mortem radiographs of easily identifiable man-made (and most often handmade) restorations. Unlike the minute detail of the wheels and ovals of fingerprint evidence, dental radiograph comparisons are often so obvious that a reasonable person is able to say that the images belong to the same person.

Other aspects

Aside from identification case work, odontologists are asked to provide medico-legal opinions on a variety of topics not included in the introduction. Bite mark interpretation, for example, is most recognizable of these to the lay audience and involves the assessment and interpretation of the true extent that is suspected of being caused by human teeth. This is fraught with difficulty, as the highly subjective nature of the comparison makes it completely based upon opinion rather than scientific research. There are so many problems associated with the interpretation of bite marks that to describe them all here is beyond the scope of this introductory article.

Cranio-facial trauma analysis is a growing area of forensic odontology practice, and involves maximisation of both living and deceased individuals and the provision of opinions concerning accurate and anatomical description of the injuries (Fig. 3), degree of force (micro-trauma, macro-trauma), and direction of force application. Occasionally, opinions are also sought regarding the exact nature of the weapon used, although caution needs to be exercised in this regard, as regardless of the implement bears unique characteristics that are imparted to the body interpretation will be very difficult. This area of odontology practice predicates a thorough knowledge of cranio-facial anatomy, the biomechanics of bone, and the effect on anatomical structures of various degrees of force.

Age estimation has always been a function of the forensic odontologist, and traditionally has been based upon comparison of dental development and comparison with published standards for tooth eruption (Fig. 4). The majority of age estimation has been based upon the eruption of the deciduous dentition of children up to 15 years. Beyond this age, dental development has become unreliable, as only the third molar is available for assessment, and this tooth is notoriously vari-
Dental tribology is capable of providing rapid and relatively cost-effective identification of the deceased, as long as reasonable ante-mortem dental records are available. In countries such as Australia, the laws concerning medical record-keeping ensure that dental records are, in the main, of good quality and easily retrieved in the event they are required.

In other countries, this may not be the case, and identification of the deceased in some parts of the world represents a serious and ongoing issue for governments and humanitarian organisations. Good record-keeping is not only of benefit to forensic practitioners, but also relevant to the work of odontologists in less developed parts of the world to encourage good record-keeping. The benefit of good record-keeping can be seen in recent mass fatality incidents, such as the Victorian Black Saturday bushfires, where, despite the availability of a well-resourced DNA capability, more than half of all victims were identified by dental record comparison.

The scope of forensic odontology is broader than identification alone and encompasses a range of activities, anything in fact where the practice and theory of dentistry intersect the law. To be a competent practitioner in this discipline requires not only a comprehensive understanding of odontology theory and technique, but also a degree of knowledge and experience in a variety of forensic fields, including law, pathology, clinical forensic medicine, molecular biology and anthropology. The forensic odontologist encounters all of these disciplines in different case scenarios, and in order to understand how the odontologist can contribute best to an investigation he or she needs to comprehend the capabilities and limitations of these fields.

Consequence

Forensic odontology is capable of providing rapid and relatively cost-effective identification of the deceased, as long as reasonable ante-mortem dental records are available. In countries such as Australia, the laws concerning medical record-keeping ensure that dental records are, in the main, of good quality and easily retrieved in the event they are required.

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