Comparison of antemortem and postmortem dental records for confirmation of identity of human dental remains in Manitoba

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Forensic dentistry has been an advancing field in forensic medicine since the 1800's and has over the years, proven its value both in single-victim situations as well as in mass disasters. The first historically documented identification case using forensic odontology associated with mass disasters was in the 1849 Vienne Opera House fire and later again during World World II (Bowers, 2011). However it was not until quite later in the 1960's, when forensic odontology was used more consistently as a tool for primary identification purposes (Bowers, 2011). In 1982, Interpol established the Disaster Victim Identification committee to develop response guidelines in the event of mass disasters (Bowers, 2011). The Disaster Victim Identification Guide offers recommendations on training and preparedness with regards to forensic odontology and it continues to be regularly updated with the most current addition being published in 2014.

Forensic odontology has become an effective medico-legal method to identify human remains. Forensic odontologists work alongside law enforcement agencies and other forensic groups to establish an unknown person's identity. In such instances of unknown identity, a fingerprint or DNA are commonly-used and trusted methods of identification (Hershaft, Alder, Ord, Rawson, & Smith, 2006). The protective location of teeth in the jawbone can make dental pulp a preferred source of DNA retrieval (Higgins, & Ausin, 2013). While a reliable method of identification, DNA is dependent on the conditions of the remains and can take several months to receive results. In most cases, fingerprints and dental comparison provide the majority of positive identifications (Bowers, 2011) with the latter being most valuable in cases of dismemberment, drowning, and incineration (Avon, 2004).

Teeth are able to resist destruction from agents that would otherwise decompose soft tissues of the body and they have high morphological variability, and thus are a valuable identification tool in forensic identification (Pereira & Santos, 2013).

Teeth, like other hard tissues, tend to remain preserved even after death and remain essentially intact even after other soft tissues of the body have been damaged due to decay or incineration (Verma, 2014). At times when the soft tissues of body are absent or destroyed and the body is unrecognizable, teeth remain virtually intact (Bowers, 2011). In the case of incineration, teeth can withstand elevated temperatures and remain intact after fingerprints and other sources of DNA degrade. Teeth can withstand temperatures of up to 1600°C while maintaining the majority of their microstructure (Verma, 2014). Also, certain dental materials have the ability to resist very high temperatures of up to 1450-1500°C. The different melting points of dental materials and the destruction of these materials can actually help determine the temperature of a fire.

After extreme destruction, the only way to make an identification is with the intervention of forensic dentistry (Pereira & Santos, 2013). Often due to the condition of the postmortem (PM) remains, forensic dentists are called upon when all other methods of identification are not possible. One of the roles of a forensic odontologist is to perform an oral autopsy on the decedent (Hershaft et al., 2006). In the instance of missing teeth, forensic odontologists are trained to determine whether missing teeth are from an antemortem (AM) extraction or postmortem avulsion due to trauma (Hershaft et al., 2006).

Forensic odontology can also be utilized for dental age estimation. This can be extremely valuable when identifying unknown victims by offering a starting point to aid in narrowing potential matches into sex and ethnic group (Manigandan, Sumathy, Elumalai, Sathasivasubramanian, & Kannan, 2015).

Forensic odontology has proven to be critical in the identification of victims in mass disasters, to alert next of kin, and to allow timely issuing of death certificates. For example, forensic odontology was critical in the identification of the victims in the American Airlines Flight 191 disaster in 1979 in which 274 people died. Of the 274 identified, 90% of the identifications where achieved via dental identifications (Senn & Weems, 2013). More recently, when the September 11th attacks claimed over 3000 lives, a significant majority of bodies were badly damaged and only 1626 victims were identified (Senn & Weems, 2013). Of the positively identified, 596 were achieved through forensic odontology (Bowers, 2011). These positive identifications using forensic odontology methods were achieved months ahead of those victims identified utilizing DNA results, thus allowing the prompt return of remains to families for proper obsequies and grief resolution. Other mass disasters that have utilized forensic odontology include natural disasters such as Hurricane Katrina in 2005. This particular event presented a particular challenge for dental identification as many of the dental offices along with their dental records were devastated by the hurricane, rendering them unusable to the forensic odontologists (Senn & Weems, 2013).

In response to the events that occurred on September 11th and to other acts of bioterrorism, organized dentistry has come together to develop legislation that

can allow dentists to assist other trained medical workers and health care workers in an event of a federally declared emergency (Hershaft et al., 2006). The efforts of these teams and forensic dentists not only help identify victims in a timely matter, but can bring emotional closure to families. Forensic dentists are also involved with diverse medico-legal issues where they are often called upon for their expert dental opinions, however their practice is predominantly involved with identification of missing and unknown persons (Bowers, 2011). Their expert testimony in a court of law can be valuable in a criminal case involving a homicide, assault, or abuse. In these instances, teeth can also be used as weapons and bite marks can be examined as dental evidence (Avon, 2004).

Laws have been established which allow law enforcement agencies and investigating agencies to obtain health records during an investigation (Hershaft et al., 2006). Under The Fatality Inquiries Act of Manitoba, the Chief Medical Examiner will often request dental records of the deceased to aid in identification of the decedent. According to the Personal Health Information Act, collection of personal information is restricted unless for a lawful purpose (Government of Manitoba, 2017). The Chief Medical Examiner may give authorization in writing to disclose or release information without causing a breach of privacy of a third party (Government of Canada, 2017). Additionally, law enforcement officials may also request the required information through use of the legal process (Hershaft et al., 2006). The original records are to be provided to the authorities during the investigation, and a legible copy of the chart should be made and maintained by the

dental office (Hershaft et al., 2006). Otherwise, if the records become lost or misplaced, the investigative process can be impeded (Hershaft et al., 2006).

Not only is a dental record a medico-legal document, it holds valuable information about teeth that will be unchanged even beyond life. Accurate and complete dental chartings should include all restorations and extractions. Thorough charting provides the ability to track the changes in a person's dentition throughout their lifetime. In addition to dental charting and daily treatment notes, radiographs, photographs, study casts, and lab tests are important parts of the patient's dental records (Avon, 2004).

According to Avon (2004), dental records should be kept for a minimum of 7 to 10 years. In Manitoba, the Manitoba Dental Association does not have specific bylaws for retention of records and the legal recommendations vary (Government of Manitoba, 2017). According to the Canadian Medical Protective Association, physicians are advised to retain their medical records for at least 10 years in Manitoba (CMPA, 2013). These guidelines vary according to each of the provinces across Canada. In some American states it is required that a patients' dental chart be kept for up to 7 years (Hershaft et al., 2006*).*

Some elements of a dental record are vital in assisting a forensic odontologist in making a positive identification. Due to their accuracy and reliability, dental radiographs are the method of choice in identifying remains when comparing AM and PM records (Avon, 2004). Thus the importance of appropriate exposure, careful handling, and storage of the radiograph is paramount so that it can be preserved for years. Dental radiographs in particular, allow for the comparison of maxillofacial,

tooth, and dental restorative characteristics that are unique to an individual (Hershaft et al., 2006). Radiographs are objective and less likely to include human errors that can be found in the written AM charts and records, and thus are considered the gold standard when comparing AM records to PM records (Hershaft et al., 2006).

A forensic odontologist can use AM radiographs to either identify or exclude the identity of the deceased. The forensic odontologist will reach a conclusion using the fundamental principle of comparison and exclusion when analyzing the AM and PM dental information (Avon, 2004). Depending on the amount of dental information available, four conclusions can be made including a: positive identification, possible identification, insufficient evidence, or exclusion (Hershaft et al., 2006). In a positive identification, there are sufficient details that match in the AM and PM records to confirm that the information is from the same individual and that there are no discrepancies. In a possible identification, there is consistency in the features between the AM and PM data. However if the quality of the data collected is poor or there is insufficient AM or PM information, a positive identification may not be possible. When there is insufficient evidence, there is inadequate data to be able to arrive at any conclusion. Finally, an exclusion is defined by the fact that AM and PM data do not match (Verma et al., 2014). In the situations of an exclusion, a PM report is not generated. Ultimately, the success of the identification relies greatly not only on the availability, but is greatly impacted by the quality of these records (Avon, 2004). Detailed and accurate AM dental

records, especially high quality radiographs, will assist the forensic odontologist in arriving to these conclusions (Hershaft et al., 2006).

Methods

This was a retrospective chart review of antemortem (AM) and postmortem (PM) dental records obtained from the Manitoba Medical Examiner's office from January 2006 - July 2017. The purpose of the study was to evaluate the presence of set variables in the AM dental records and to assess if complete or partially complete AM records facilitated identity confirmations of decedents. Ethics approval for this retrospective study was obtained from the University of Manitoba Health Research Ethics Board (HREB). A Data Capture Sheet was devised to obtain and filter information from the AM and PM chart sources. All information related to the chart review used in this study was stripped of patient identifiable markers and each chart was given a unique identification number. AM dental records were evaluated for the presence of dental radiographs, clinical charting, and a current dental odontogram. A total of 162 AM and PM reports having been completed by the dental forensic team were reviewed. Of the 162 charts, 105 charts resulted in positive identifications. The data capture sheet recorded: age at time of death/PM examination, presence of AM records, types of dental examinations, frequency and types of intraoral and extraoral radiographs, quality of radiographs, presence and quality of dental odontogram, presence of daily clinical notes, currency of records, time elapsed since last radiograph and clinical charting, PM identification conclusion, reason for inability for positive identification (if applicable), age estimation (if applicable), and state of remains during the PM dental examination.

This compiled data was then transferred to an excel spreadsheet which was subsequently analyzed by a statistician and descriptive data was interpreted.

Results

Of the 105 charts analyzed in the positive identification group (PIG), the average age of the decedents at the time of death was 43 years with an age range of 6-86 years. With respect to gender, 70% of the decedents were male and 30% were females (Table 1). In this group, 96% of the decedents had antemortem (AM) radiographs available for analysis, while 87% had AM clinical charting (Table 2). Of the different types of dental examinations that were noted in the clinical charts, recall examinations were observed more frequently (81%) versus specific examination (19%) (Table 4). Furthermore, as shown in Table 3, the mean number of recall exams per decedent was on average 6.03, while it was 1.48 for the specific exams.

Table 1. Positive identification group demographic (n=105)

Variable	
Average age at time of death	43
Median age at time of death	44
Range of age at time of death	6-86
Number of males	73
Number of females	32

Table 2. Decedents that had AM exams and radiographs available (n=105)

Variable	Total	Available (%)	Not Available (%)
Exams	93	88.57	11.43
Radiographs	98	96.15	3.85

Table 3. Mean number of AM exams and radiographs per decedent

Type of Exam	**Mean**
Recall exams	6.03

Specific exams	1.48
Radiographs	12.02

Table 4. Distribution of types of exams in AM dental records (n= 752)

Type of Exam	Total	Mean
Recall exams	610	81.10%
Specific exams	142	18.90%

Of the 105 dental records analyzed in the PI group, 5 of the clinical charts had missing AM radiographs. A total of 1174 AM radiographs were available for analysis, with the mean number of AM radiographs per decedent being 12.02 (Table 3). Of the 1174 radiographs, the majority of the radiographs were bite-wings (49.15%) and periapicals (46.85%) as shown in Table 5. The remaining distribution of AM radiographs comprised of panoramic radiographs (3.15%), lateral cephalometric radiographs (0.034%), and intraoral photos (0.51%), and there were no occlusal films. Of the 100 clinical charts that had AM radiographs for analysis, 90% of them had at least 1 bite-wing radiograph and 78% had at least 1 periapical radiograph. Additionally, 34% of the charts had a panoramic, 4% had a lateral cephalometric, 3% had photographs, while none of the decedents had any occlusal radiograph available for analysis (Figure 1).

Table 5: Total number of radiographs available (n=1174)

Types of radiographs	**Total**	**Average (%)**
Periapical	550	46.85
Bite-wing	577	49.15
Occlusal	0	0
Panoramic	37	3.15
Lateral Cephalometric	4	0.034
Photographs	6	0.51

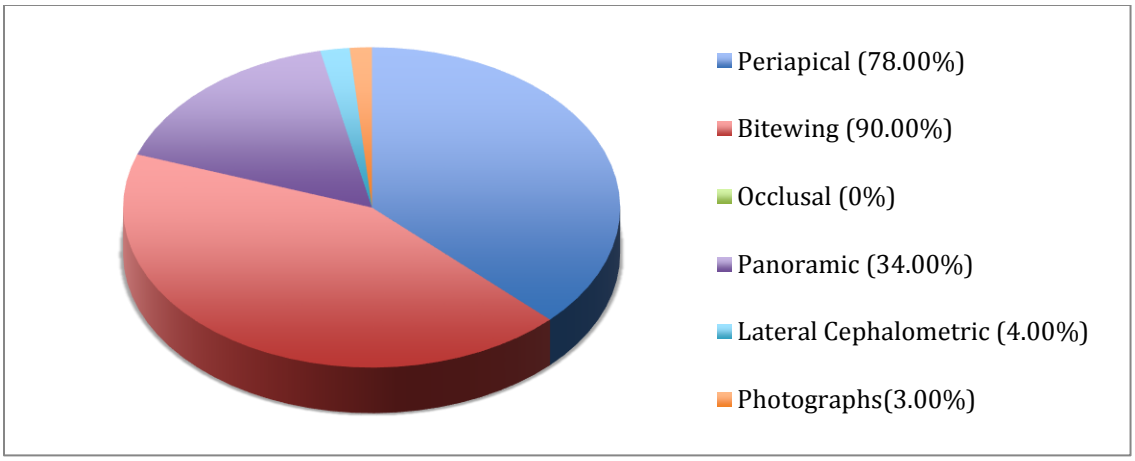

Figure 1: Average radiographs available amongst PI group (n=100)

AM radiographs were additionally evaluated for the quality of the radiographs and the presence of appropriate identification and labelling. As shown in Table 7, the overall radiographic labelling was acceptable (98.00%), however 10% of radiographs contained an error with labelling of a missing name or date. The quality of radiographs was on average deemed acceptable (98.99%) (Table7), however 14% of these were associated with a series of radiographs that contained one or more radiographs that had at least one of the following radiographic errors: cone cut, fixer contamination, overexposure, underexposure, tape obstruction, bending/mishandling of radiograph, or presence of artefact. The frequency and types of radiographic errors are depicted in Figure 2.

Table 7. Identification/labelling and quality of AM dental radiographs

Criteria	Acceptable (%)	Unacceptable (%)
Radiograph identification/labeling (name and date)	98.00*	2.00
Radiograph quality (cone cut, fixer contamination, overexposure, underexposure, tape obstruction, bent/mishandling of radiograph, or had presence of artifact)	98.99**	1.01

** Of the 98% radiographs that were deemed acceptable, 10% of these were associated with a series of radiographs that contained one or more radiograph that had either missing name or date*
*** Of the 98.99% radiographs that were deemed acceptable, 14% of these were associated with a series of radiographs that contained one or more radiograph that had one of the following radiographic error: cone cut, fixer contamination, overexposure, underexposure, tape obstruction, bent/mishandling of radiograph, or had presence of artefact*

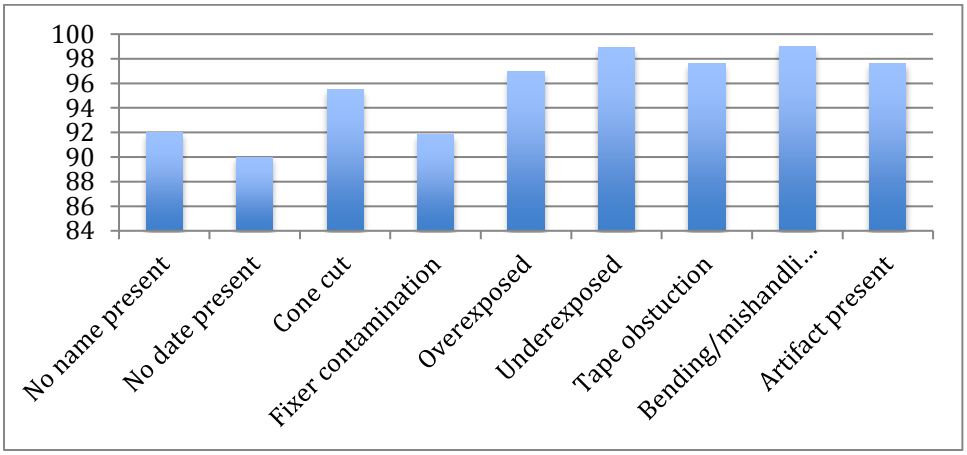

Figure 2. Type of errors found in AM radiographs

The variable clinical charting present was assessed and present in 88% of the AM dental records, with a dental odontogram present in 75% of the dental records (Table 9). Furthermore, the dental odontogram was also evaluated for quality and thoroughness. Table 10 shows that the dental odontogram was complete in 36.2% of the cases, partially complete for 25.7%, incomplete for 13.3%, and not available in 24.8% of the cases.

Table 9. Presence of clinical charting notes and dental odontogram available in AM dental record

Variable	Available (%)
Clinical charting present in chart	88
Odontogram present in chart	75

Table 10. Completeness of dental odontogram in AM clinical chart

State of odontogram	Mean (%)
Complete	36.19
Partial	25.71
Incomplete	13.33
Not available	24.76

The currency of AM dental records was calculated from the last documented clinical entry in the AM dental record and are shown in Figure 3. The time elapsed ranged from 1-374 months. On average, 68% of the dental records were under 1-2 years from the time of the PM examination, 20% between 3-5 years, 6% between 5-9 years, 2% between 10-14 years, 1% between 15-20 years, and 3% over 21 years had passed. The average times elapsed since the last radiograph was taken until the time of PM examination was 43 months and for the clinical charting, 32 months (Table 12).

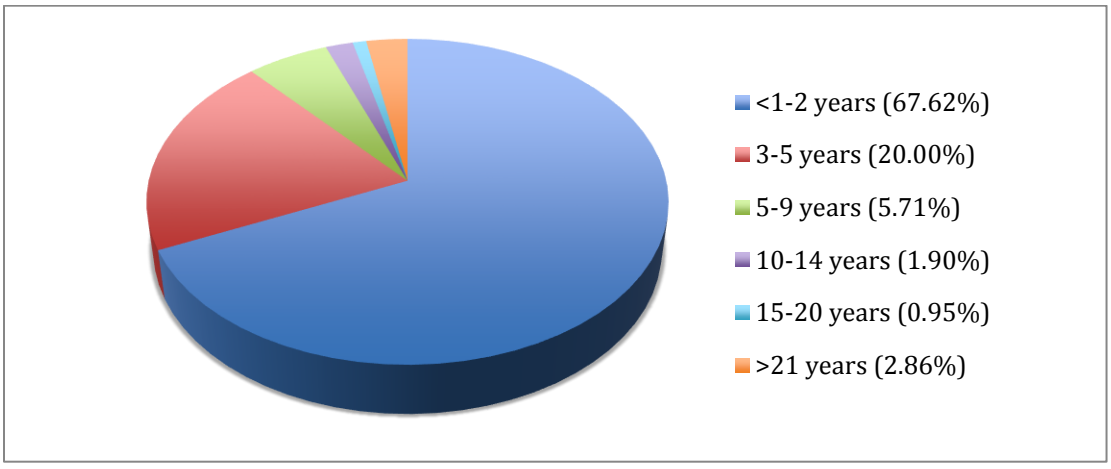

Figure 3. Currency of antemortem records

Table 12. Average time elapsed in months since last radiograph or clinical charting from PM examination

Time elapsed since entry	Months
Radiograph	42.27
Clinical charting	31.78
Range in months for radiograph	1-374
Range in months for clinical charting	1-307

During the PM examination, the dental remains were categorized depending on their condition at the time of examination. The dental remains presented as complete and intact 80% of the time, as partial dentition present 12%, with missing teeth 11%, as incomplete maxilla 6%, as incomplete mandible 6%, with fractured teeth/roots 8%, and as charred crowns/roots 8% (Figure 4).

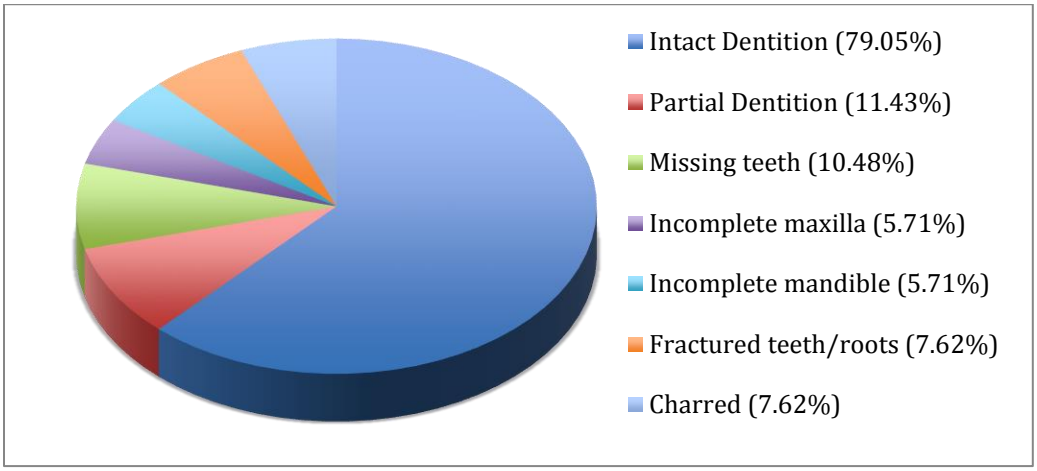

Figure 4. State of dental remains during PM examination (n = 105)

Of the total 162 charts analyzed, the dental forensic team was unable to positively identify 57 decedents and this group was excluded from the study. Of the 57 dental records in the non-positive identification (NPI) group, there were 6 decedents that did not have any AM dental records available, and 25 decedents had missing/insufficient information in either their AM or PM dental records due to either insufficient quantity or quality of the dental records. Additionally, 16 charts

had already been returned to the dentist, and 6 cases were age estimations (Table 14). For these reasons, positive identifications of the unknown decedents could not be attained. Of the 25 dental records with missing information, there were 20 cases that were concluded to be possible identifications and 5 that had insufficient evidence to make a positive identification (Table 15).

Table 14. Reason for non-positive identifications (n= 57)

Variable	Frequency
No dental records available	7
Missing/insufficient information*	25
Charts returned	16
Missing PM dental report	4
Could not locate dentist	1
Age estimation case only	6

**Quality/quantity of AM records, quality/quantity of PM records*

Table 15. Identification conclusion of NPI group that had missing/insufficient information in antemortem dental records (n=25)

Identification conclusion	Frequency
Positive ID	0
Possible ID	20
Insufficient evidence	5
Exclusion	0

Finally, the reasons for the insufficiency in AM dental records resulting in the inability to positively identify the decedent was due to inadequacy in the: AM records, PM records, or both AM and PM records. There were 12 charts that could not be positively identified due to the quality of the AM dental records, 15 charts due to the quantity of AM dental records, 3 charts due to the quality of the PM records, 2 charts due to the quantity of the PM records, 2 charts due to quality of both AM and PM records, and 3 charts due to the quantity of both AM and PM records (Table 16).

Table 16. Reason for insufficiency in antemortem dental records resulting in the inability to positively identify the decedent (n=25)

Reason for insufficiency	Frequency
Quality of AM records	12
Quantity of AM records	15
Quality of PM records	3
Quantity of PM records	2
Quality of both AM and PM records	2
Quantity of both AM and PM records	3

**Some radiographs applied to more than 1 category*

Discussion

In the PI group, it was observed that the majority of the decedents identified were male (70%). In Canada, males are two times more likely to be victims of homicide than females (Basham & Snider, 2016). These rates are associated with community risk factors such as populations living in disadvantaged neighbourhoods, lower socioeconomic status, and societal factors such as weapon availability, income inequality and media influences (Lachaud et al., 2017). Additionally, a trend in homicide mortality rates have been increasing over the years, with Manitoba having the highest homicide mortality rates for both men and women across Canada, with a particular increase in males (Basham, & Snider, 2016).

As we know, dental visits can include a range and variety of dental procedures depending on the nature and the urgency of the treatment required. Some patients visit a dentist on a regular basis, while others attend only in times of need. For these reasons, different types of dental examinations are useful to help diagnose certain problems at a given specific circumstance. When evaluating the breakdown between the types of examinations performed in the AM dental records, there was a notably higher rate of recall examinations. This was particularly helpful

for a positive forensic odontology identification, as these examinations tend to be more thorough and thus include a more in-depth treatment planning and detailed charting. In contrast, specific exams tend to deal more with a localized problem and often result in limited treatment and charting of a specific area only. Recall exams, being more comprehensive in nature, often will include a series of check-up radiographs. This is relevant as it provides a snapshot of the general or overall condition of the dentition at that time. This provides an important dental overview when used for forensic dental identification. Their importance was evidenced by the presence of AM radiographs in 96% of the positive identifications.

Although a dental odontogram can also arguably provide as general a dental overview similar to radiographs, its practice appears to be underutilized. This is evidenced by the fact that 75% of the AM dental records possessed a dental odontogram and of these, only 36% were completed. Possible reasons for the missing dental odontograms may be due to the older chart templates that had limited space for a complete odontogram or due to the general lack of awareness of the importance of the clinical odontogram. A limitations of a dental odontogram is that its maintenance requires more effort and can be time consuming. Moreover, it can be subjective, such as in the instance of differing opinions of existing molars. They also may contain human errors such as improper identification of present/missing teeth and charting missing third molars incorrectly (Shiroma, 2016). Despite these limitations, the dental odontogram is still a valuable record in the absence of radiographs. The odontogram will offer detailed information that the daily clinical charting may preclude such as prior existing restorations and missing

teeth. The odontogram is a vital part of a dental record as it represents the state of the dentition at the last dental visit. More efforts should be taken to ensure that the dental odontograms are part of the overall dental records and that they are regularly updated to reflect treatment provided.

Fortunately even in the absence of the dental odontogram in the AM dental records, positive identifications still can be made in the presence of the clinical charting and dental radiographs. Of the different types of radiographs available, it comes as no surprise that the frequency of bite-wings and periapicals are noted n=577 and n=550 respectively, as they are the types of radiographs that are most associated with diagnostic images during routine dental treatment. Panoramic films (n=37) were less common amongst the AM dental records, which is consistent to the norm when considering the reasons for their use. In a general private practice setting, panoramic radiographs are only prescribed in specific circumstances partly due their cost, the amount of radiation emitted, and their availability as not all offices have the equipment required for this type of radiograph. In addition to these reasons, the fact that many insurance plans do not cover this type of radiograph will often preclude their use with patients declining these radiographs, ultimately resulting in a lesser frequency of their use in general practice. Lateral cephalometric radiographs had a an even lower frequency (n=4), and are less likely to be taken as this type of film tends to be mostly prescribed for the use in orthodontic cases (which generally involves a younger cohort of individuals). In our study, the average age of the decedents was 42 years, which correlates to the low number of lateral cephalometric radiographs observed. Furthermore, when a person is identified as

missing or requiring forensic odontology for the identification of remains, the police or RCMP will contact the decedent's general dentist, not the specialist who would have this type of specialized radiograph (orthodontist or oral and maxillofacial surgeon). Only 6 intra-oral photographs were present amongst the AM dental records analyzed, which is unfortunate as the benefit of photographs in identifying an unknown decedent has been demonstrated in literature. In the absence of AM dental records, AM photographs have been used to identify a decedent via analysis of the smile line and image superimposition (Miranda, Fitas, Maia, & Melani, 2016). There has been an increasing trend of many general practice offices taking photographs of patients for the purpose of inclusion in the patient profile. This could prove useful for identification purposes as an adjunct to other components of the dental record.

The importance of dental radiographs in the application of forensic dentistry has been the focus up to this point. However, as helpful as they can be as a tool, their application relies greatly on the adequacy of their diagnostic quality. Labelling errors in addition to errors in their processing and handling can hinder the forensic identification process and ultimately make their use ineffective. Evaluation of these criteria revealed that the overall diagnostic quality and labelling was acceptable at 98%. The highest errors observed were due to fixer contamination (8%), missing name (8%), and missing date (10%). Although these errors seem relatively low, their presence nonetheless can exclude them from being used in medico-legal and forensic odontology identification. Fortunately, with the trend moving towards

digital radiographs, it is predicted that the above-mentioned errors will no longer be factors.

Alongside the trend regarding digital radiography, there appears to be the same movement towards electronic charting and dental practices transitioning into paperless dental practices. This could prove useful for many reasons, including readily retrievable data that could eliminate confusion and delays by making the information more accessible and easier to interpret/obtain at a later time. Upon analysis of the AM dental records, there were clinical charts that bared illegible handwriting and instances where non-universal short hand terminology or acronyms were used. For these reasons, the clinical charting notes were difficult to decipher and the overall task was more time-consuming. Non-universal shorthand or abbreviations can make it more challenging for forensic odontologists to readily interpret the information and thus decreasing the chance for an accurate comparison of the AM and PM dental records (Hershaft et al., 2006). Universal standards for dental charting allow for the AM records to be easily interpreted. Additionally, electronic formatting of data entry could greatly improve efficiency of accessing information in a chart and prove beneficial during audits and during medico-legal or forensic investigation. In terms of storage, electronic charting could also prove advantageous is many ways. Paper charts require physical space for storage and can be more difficult to access once stored. Electronic dental charts on the other hand, can be easily backed up onto a server and be re-accessed at a later time from almost anywhere. The convenience of this method could further

encourage dental offices to keep patients charts for longer as it is generally suggested to keep the records beyond the minimal recommended years.

The results of this study demonstrate the utility of keeping dental records beyond the recommended years. Some of the AM records dated back over 32 years and have assisted in attaining positive identifications. Although the majority of the AM dental records (67%) were under 1-2 years from the time of the PM examination, it is without doubt that the older entries still played a vital role in the remaining positive identifications.

It is evident that the AM information gathered is paramount and that without this data the identification cannot be achieved. The second part of the study involved comparing the collected AM data to the same type of data obtained from the dental remains during PM examination. Fortunately, the majority of the dental remains examined by the forensic odontologists were intact, which made the positive identifications more readily achievable. In the instances where only partial dentition remained or missing teeth were present, these cases presented more of a challenge for the dental investigator. In these circumstances, it is important for the forensic odontologist to determine if the missing teeth occurred antemortem or postmortem. PM missing teeth, especially those that are single-rooted, are common as their anchorage in the bone is not as great as that of molars. Single-rooted teeth tend to become avulsed more easily in the event of trauma or loosened over time from softening of bone in the instance of extended amounts of time submerged. Knowledge of dental anatomy is paramount when retrofitting the avulsed teeth back into their positions in the jaw. Studies have shown that a single tooth could result in

a positive identification (Avon, 2004). Another challenge for forensic dental identification is when only segments of the maxilla or mandible remain. Upon PM examination of charred dental remains, it has been observed that the anterior segments of jaws tend to be more exposed and become charred more easily, whereas the posterior regions remain protected from soft tissues (Hershaft et al., 2006). However the position of the decedent along with the intensity and duration of time in the fire can greatly impact this as well (Hershaft et al., 2006). During extended exposure to high temperatures, the enamel and dentin can fracture off the teeth, making identification even more difficult (Hershaft et al., 2006). Fractured and charred teeth are not uncommon in the event of extreme trauma and fire, or if the remains are old and become brittle. At times entire arches can be missing, with the mandible being more commonly detached due to trauma or removed by scavenging of wild animals. If by chance the mandible is recovered, at times the cartilage is missing from the condyles which makes the refitting the mandible to the maxilla more challenging.

Of the total 162 charts analyzed, 57 charts had insufficient data present and the decedents could not be positively identified. A good portion of these cases comprised of decedents whose dental records were previously returned to their dentist. Additionally, there were 11 cases that were excluded from the study as there were no dental records available. This could have been due to the fact that these decedents never had dental treatment or that there was not enough information on the decedent to be able to compile a list of possible names. Of the remaining cases, 4 PM dental reports were missing, which excluded them from the

study. PM dental reports hold the information about the identification conclusion made by the forensic odontologist following the PM examination. Without them, we do not know the conclusion of the investigation. For the remaining 25 charts, the forensic odontologist could not reach a positive identification due to missing information. Most commonly it was the quality and quantity of the AM records that was insufficient.

The majority of the conclusions obtained from the PM dental reports in this non-positive identification group were comprised of possible identifications. This meant that there was a discrepancy present in the AM and/or PM records that did not allow for a positive identification. In a possible identification, there is consistency in the features between the AM and PM data; however due to poor quality or insufficient AM or PM information, a positive identification is not possible. Such discrepancies can be observed when large amounts of time have elapsed between the last dental charting and the time of death. For example, if a missing tooth with a healed socket was noted during the PM examination, but the same missing tooth was not noted in the AM dental records as missing, this information alone can preclude this case from a positive identification, even if all other information such as restorations and other missing teeth were consistent. It could very well be that this tooth was extracted antemortemly, but without the AM records confirming such a finding, the forensic odontologist cannot confirm a positive identification.

Among the NPIG, 6 cases were age estimations. The decedents in the age estimation cases were analyzed by the forensic odontologists to provide

identification via analysis of the dentition in relation to age. Age estimation can be valuable in narrowing possible identities in the presence of an available pool of decedents. Age estimation is a sub-discipline of forensic sciences and which relies on analyzing the formation pattern and the sequence of eruption of teeth (Hershaft et al., 2006). There are two methods by which age can be assessed via dental examination: with the use of radiographs and through visual inspection.

A complete dental record should record the patient at baseline and should include the following: the patient's demographic information, regularly updated medical information, chief complaint, past dental history, charting on the extraoral and intraoral examination, charting of hard and soft tissues of the head and neck, radiographs of diagnostic quality, all restorations and caries present, daily treatment record, referrals, consent, and treatment that has been refused by the patient (Hershaft et al., 2006).

Regrettably, many records are not complete and only include the dental treatment that has been completed or that needs to be done (Hershaft et al., 2006). Dental records that were sampled by forensic odontologists in a study demonstrated a lack of important details that would have proven valuable to a forensic dentist and which also failed to comply with record-keeping guidelines (Stow, James, & Richards, 2016). Poorly maintained records not only result in confusion, but incomplete charting gives the odontologist very little to no information required to make an identification (Avon, 2004). In fact, incorrectly charted and errors in teeth numbering has led to false positive identifications (Lorkiewicz-Muszynska, Przystanska, Glapinski, Kociemba, & Zaba, 2013). Lack of

dental records or incomplete dental records can delay or prolong the investigation and prevent a positive identification to be resolved in a timely matter. For the families of the deceased, this is a huge disfavour as emotional closure cannot be attained.

Conclusion:

The foundation of good patient record keeping for the majority of dentists is learned in dental curriculums. Research has shown that complete and accurate records are most often kept by young dentists, female dentists, and specialists (Pessian & Beckett, 2004). Teaching the fundamentals of comprehensive dental records is the duty of dental schools, however the students are just as accountable. Without the willingness of the students to participate and practice such standards, these skills will not be maintained throughout their career.

Compiling a complete dental record is not only a component of high standard of care, but is also a legal document that can used in a court of law. According to Pessian and Beckett (2004), the standard of record keeping can be improved through the awareness of the importance of good dental record taking. It is also suggested that more clear guidelines from leading health authorities can help improve maintenance of dental records of private clinics (Waleed et al., 2015).

The results of this study demonstrate how complete and accurate AM dental records are necessary in order to provide forensic odontlologists with the essential data to make comparisons and conclusions regarding the identification of human remains. Well-kept and detailed dental records allow for expeditious identification which can help return remains for burial/obsequies and bring emotional closure to

families. This can be achieved if the dental team members understand the vital role they can play in forensic dentistry and continue to maintain high standards of record keeping.

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