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Contents

RECESSION OF PERIODONTAL LIGAMENT AS AN INDICATOR OF AGE

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ABSTRACT

The recession of the periodontal ligament has been used as one of several indicators of age in methods for age estimation. In a sample of 1000 teeth the relationship between age and periodontal recession was studied for each type of tooth. Only a weak correlation was found, the least weak being for premolars. The mean of the periodontal recession measured in mm showed approximately the same correlation as when assessed by scoring systems. Logarithmic transformation of the mean of the recession resulted in a stronger correlation with age. The use of tooth age rather than individual age did not have the same effect. Periodontal recession tended to be more rapid in males than in females. The reason for extraction was not found to be significantly correlated with periodontal recession. In conclusion, periodontal recession was not sufficiently accurate to be used as a sole indicator of age. However, in multiple regression methods for age estimation it might contribute significantly to the age equation, especially for premolars.

Key words: teeth; ageing; sex; periodontal recession.

INTRODUCTION

Destruction of periodontal fibres results in loss of dental attachment to the alveolar bone, which eventually results in exfoliation of the tooth. Measurements with a periodontal probe of the gingival pockets are taken to indicate the extent of a patient's loss of fibres. On extracted teeth it is measured as the distance from the cemento-enamel junction to the most gingivally remaining fibres on the root.[1]

The reason for the loss of periodontal attachment may either be a continuous tooth eruption throughout life to compensate for attrition [2,3,4] or a plaque-induced chronic periodontal inflammation starting at the gingival margin [4,5,6]. as both of these processes usually progress slowly and require many years before a major part of the root has lost its periodontal fibre attachment, it has been difficult to establish which process predominates. Recession of the periodontal ligament has been taken as an indicator of human age and has been applied together with other age-related changes in methods for age estimation [7,8,9]. However, large individual variations in periodontal destruction have been observed, and in the absence of intervention, every individual in a rapid progression group had lost all teeth at an age of 45 years[10].

In these methods the recession of the periodontal fibres has been assessed according to scoring systems. This has been criticised because determining the score is to some extent subjective[11]. Measuring the distance from the cemento-enamel junction to the upper periodontal fibres with a pair of vernier calipers may be more objective and could be better related to age. Such measurements have not been used in statistical methods for age estimation in any previous study.

The aim of this study was to establish the relationship between age and the loss of periodontal attachment by various methods of measurement. It was also the intention to study the relationship between periodontal recession and the sex, the reason for extraction as well as the relationship with attrition. A further aim was to find a formula for age calculation by means of multiple regression analysis of assessments of periodontal recession and to evaluate what this factor might contribute to multiple regression methods based on several different types of dental age changes.

MATERIALS AND METHODS

The material, described in previous reports [12,13], comprised 1000 extracted teeth from a Caucasian population, 100 teeth of each type, excluding molars. Most teeth had been extracted in dental practice for different reasons, but some originated from cadavers or dental identification cases. The teeth were stored in neutral buffered 4% formaldehyde solution.

After careful cleaning of the root surface without destruction of the periodontal fibres, the loss of periodontal attachment was measured on the mesial (PMES), vestibular (PVES), lingual (PLIN) and distal (PDIS) surfaces of the unprepared tooth, using a pair of vernier calipers. The distance from the cemento-enamel junction to the most gingival periodontal fibres attached to the root surface was measured, and the mean (PMEAN) was calculated.

The teeth were subsequently sectioned according to the "half-tooth" technique[14]. When viewed from the cut surface, the periodontal recession was scored according to the systems of Gustafson[7] (PG), Dalitz[8] (PD) and Johanson[9] (PJ). The values of Johanson's scores were doubled to avoid half units.

STATISTICAL METHODS

The data were transferred as ASCII files from a Cyber computer to a Sanyo MBC-17plus5 microcomputer and the statistical analyses were performed using the SPSS/PC+ statistical package[15].

A paired t-test for left/right differences was performed on contralateral teeth from the same individual (20-28 pairs of each tooth type). Since no statistically significant differences were detected at $p < 0.001$ level, left and right teeth were pooled for the final analyses. As these operate with the tooth and not the individual as the unit, only one from each pair of contralateral teeth from the same individual could be included in the study. The right tooth was chosen, and thus the numbers of teeth for the final analyses were reduced from 100 to between 72 and 80 for the various types of teeth.

A tooth age was calculated as the difference between the age of the individual and the age at supposed complete root formation[16]. Sex differences were taken into account. In addition, squared and logarithmic (base 10 logarithm) transformations of PMEAN were made by the computer. These transformed variables also served as a test for a non-linear relationship between age and periodontal retraction.

For each type of tooth an analysis of the mean and variation of the variable was run, using the Descriptives subprogram of the SPSS package, while the Regression subprogram was applied to calculate the correlation between age, tooth age and the independent variables. Partial correlations between the variables were also calculated by means of the latter subprogram. By including age in the regression with periodontal recession as dependent variable, partial correlation between the latter and the sex, reason for extraction, and attrition could be read, while age was controlled for. In the same way, by including the sex and reason for extraction, partial correlation between age and periodontal recession could be found while both these two factors were controlled for.

In addition, the Regression subprogram was used to analyse the relationship between age and periodontal recession while age and tooth age were alternatively applied as dependent variables. A stepwise procedure was used, with inclusion level at $P < 0.05$ and the exclusion level at $P > 0.055$.

RESULTS

Descriptive data for the material are presented in Table 1. The periodontal recession is to some extent related to mean age. Greater recession was observed in mandibular than in maxillary teeth.

Table 1

Mean values for periodontal recession scores and measurements

Tooth Type	Age Yrs	Scores PG	PJ	PD	Measurements in mm PMES	PVES	PDIS	PLIN	PMEAN
Max. 1	51.1	1.5	2.6	1.8	3.8	2.6	4.0	3.0	3.4
Max. 2	52.5	1.7	2.8	1.9	4.6	3.0	4.3	2.9	3.7
Max. 3	53.5	1.4	2.6	1.7	3.7	3.6	3.5	3.1	3.5
Max. 4	44.1	1.4	2.4	1.6	2.3	2.9	2.6	2.8	2.6
Max. 5	47.3	1.4	2.5	1.7	2.7	3.1	3.1	3.2	3.0
Mand. 1	57.9	2.2	3.6	2.6	5.9	4.8	5.7	5.0	5.4
Mand. 2	57.6	2.1	3.4	2.5	6.2	4.6	5.7	4.6	5.3
Mand. 3	59.7	1.7	3.0	2.0	5.9	4.1	4.3	4.4	4.5
Mand. 4	50.9	1.6	2.7	1.8	3.2	3.7	3.3	3.4	3.4
Mand. 5	52.6	1.5	2.7	1.9	3.2	3.6	3.5	3.6	3.5

PG = periodontal recession according to Gustafson's scores[7]
PD = periodontal recession according to Dalitz' scores[8]
PJ = periodontal recession according to Johanson's scores[9]
PMES = periodontal recession on mesial surface
PVES = periodontal recession on vestibular surface
PDIS = periodontal recession on distal surface
PLIN = periodontal recession on lingual surface
PMEAN = mean of measurements on the four surfaces

Pearson correlation coefficients between age and recession of the periodontal ligament (Table 2) were rather weak and for some teeth insignificant. The correlations for the scores (Fig. 1) tended to be stronger than for measurements on each surface, but did not differ much from those for the mean of the measurements on the four surfaces (PMEAN) (Fig. 2). After correction for the effect of extraction for periodontal reasons (PM) by dividing by 3, the means for some teeth correlated more strongly with age than PMEAN while for others it was the reverse. The squared transformation of PMEAN had weaker correlation, and logarithmic transformation (LPMEAN) a stronger correlation, than PMEAN (Fig. 3). The periodontal recession was most .pa strongly correlated with age in premolars and weakest in canines. The use of tooth age instead of individual age did not result in a stronger correlation with LPMEAN.

Table 2

Pearson correlation coefficients for age versus measurements and scores for periodontal recession. TAGE shows the correlation between this factor and LPMEAN.

Tooth	PG	PD	PJ	PMES	PVES	PDIS	PLIN	PMEAN	PM	PMEAN2	LPMEAN	TAGE
Max. 1	.32	.30	.23	.25	.31	.22	.15	.25	.20	.13	.43	.42
Max. 2	.16	.16	.26	.18	.23	.17	.11	.16	.27	.07	.34	.34
Max. 3	.01	.06	.07	.09	.08	.12	.01	.08	.12	.01	.22	.21
Max. 4	.52	.55	.50	.44	.49	.50	.47	.51	.53	.32	.64	.64
Max. 5	.42	.48	.46	.42	.46	.48	.40	.46	.31	.32	.60	.59
Mand. 1	.42	.36	.32	.25	.25	.29	.31	.29	.39	.19	.41	.41
Mand. 2	.27	.26	.22	.24	.23	.19	.23	.25	.34	.11	.42	.34
Mand. 3	.01	.09	.23	.03	.18	.20	.17	.22	.26	.14	.36	.35
Mand. 4	.47	.54	.49	.33	.50	.46	.42	.46	.33	.29	.60	.60
Mand. 5	.45	.47	.42	.37	.49	.46	.42	.46	.52	.32	.56	.56

For other abbreviations see Table 1.

PM =PMEAN divided by three in cases of extraction for periodontal reasons.
PMEAN2 =square of PMEAN.
LPMEAN =logarithmic transformation of PMEAN (base 10 logarithm).
TAGE =tooth age.

Significances limits: $P<0.05$ for $r>0.22$ (n=75)
$P<0.01$ for $r>0.29$ (n=75)

Partial correlations between LPMEAN and age after controlling for SEX and EX (reason for extraction), resulted in only minor changes from the Pearson correlation coefficients; in most teeth a slightly stronger correlation was found (Table 3). No significant correlation between the SEX and LPMEAN was found for any type of tooth. Only for mandibular canines was a significant partial correlation between EX and LPMEAN registered (r = 0.44).

Table 3

Partial correlation between LPMEAN and age after having controlled for the effect of the SEX and EX, partial correlation between LPMEAN and SEX and EX after having controlled for the effect of age and the Pearson correlation between age and PMEAN.

Tooth	Partial correlation LPMEAN/AGE	LPMEAN/SEX	LPMEAN/EX	Pearson r LPMEAN/AGE
Max. 1	.42	.09	-.05	.43
Max. 2	.35	.08	.01	.38
Max. 3	.26	.22	.08	.22
Max. 4	.62	.21	-.12	.64
Max. 5	.60	.19	.11	.59
Mand. 1	.44	.19	.14	.41
Mand. 2	.48	.21	.20	.42
Mand. 3	.40	.05	.44	.36
Mand. 4	.61	.10	.06	.60
Mand. 5	.57	.08	.16	.56

EX = reason for extraction
For other abbreviations see Tables 1 and 2.
For Significans limits see Table 2.

Partial correlations between PMEAN, LPMEAN and attrition, while AGE was controlled for, revealed only a weak and, for most teeth, an insignificant correlation.

Multiple regression analyses (Table 4) showed multiple correlation coefficients between 0.50 and 0.70 for most teeth. Maxillary first premolars displayed the strongest correlation (r = 0.67), whilst maxillary lateral incisors and in particular maxillary canines showed the weakest correlations (r = 0.25). Furthermore, the application of tooth age did not offer any advantage except for maxillary central incisors, where the sex was introduced as an extra factor.

Table 4

Multiple regression analyses of the relationship between periodontal recessions and age. The formula with the strongest multiple correlation coefficient is shown for AGE (age of the individual) and TAGE (tooth age).

Tooth	Formula	r	r2
Max. 1	Age = 47 + 34 LPMEAN - 3 PLIN	.51	.26
	Tage = 41 + 34 LPMEAN - 3 PLIN - 8 SEX	.56	.31
Max. 2	Age = 47 + 19 LPM	.38	.15
	Tage = 37 + 19 LPM	.38	.15
Max. 3	Age = 51 + 10 LPM	.25	.06
	Tage = 37 + 9 LPM	.24	.06
Max. 4	Age = 52 + 40 LPMEAN - 7 PJ	.67	.45
	Tage = 39 + 41 LPMEAN - 7 PJ	.66	.44
Max. 5	Age = 40 + 22 LPMEAN	.59	.35
	Tage = 27 + 22 LPMEAN	.59	.35
Mand. 1	Age = 53 + 23 LPM - 11 SEX	.54	.29
	Tage = 45 + 23 LPM - 12 SEX	.55	.31
Mand. 2	Age = 48 + 39 LPM - 8 SEX - .3 PM2	.57	.33
	Tage = 39 + 39 LPM - 9 SEX - .3 PM2	.58	.34
Mand. 3	Age = 53 + 42 LPMEAN - 3.0 PMES	.50	.25
	Tage = 35 + 37 LPMEAN + 11 PJ-3.5PMES-12PG	.60	.36
Mand. 4	Age = 43 + 37 LPMEAN - 2.1 PMES	.63	.40
	Tage = 28 + 27 LPMEAN	.60	.36
Mand. 5	Age = 43 + 27 LPM	.59	.35
	Tage = 30 + 28 LPM	.59	.34

For other abbreviations see Tables 1 and 2.
LPM = logarithmic transformation of PM (base of 10 logarithm).

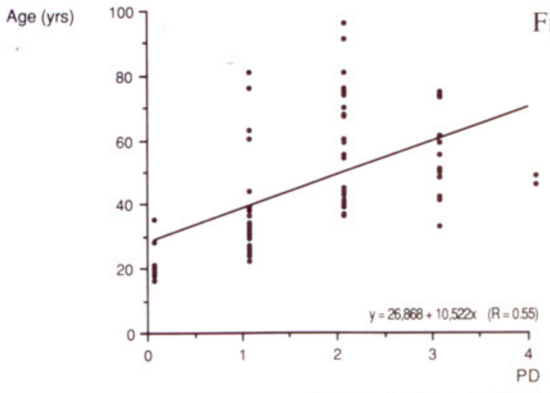

Fig. 1 Plot of age versus periodontal retraction scores according to Dalitz[8] for maxillary first premolars (r = 0.55).

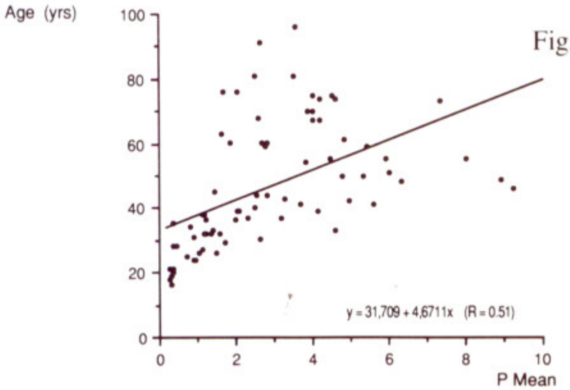

Fig. 2 Plot of age versus PMEAN (mean loss of periodontal ligament) for maxillary first premolars (r = 0.51).

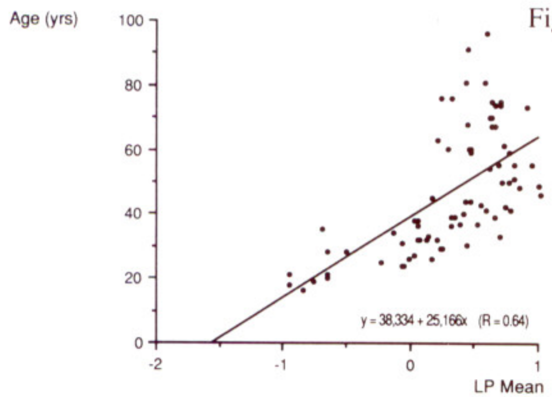

Fig. 3 Plot of age versus LPMEAN (logarithmic transformation of PMEAN) for maxillary first premolars (r = 0.64).

DISCUSSION

The teeth used in this study originated from subjects both with and without periodontal disease and might therefore be considered less suitable for a statistical study of the age-related regression of the periodontal ligament. In forensic cases, however, the degree of periodontal disease may be unknown. Thus a sample of teeth which would almost certainly include some from individuals affected by periodontitis might have reflected the biological variations better[17] than if these were excluded; it was therefore considered more suitable for this type of study.

Left/right differences in the level of the periodontal attachment might have been expected, as most people are right-handed and will more readily brush the left-side teeth. A study by Schei et al.[6] actually showed more periodontal destruction on the right side of the maxillary incisors in right-handed subjects. However, other studies[18,19,20], as well as that under discussion, failed to show significant left/right differences in periodontal recession.

Recession of the periodontal ligament was more pronounced in mandibular than in maxillary teeth. This is in agreement with archaeological findings[21] and also with the findings by Haffajee et al.[22] in a contemporary sample. The difference is, however, difficult to explain.

A much stronger correlation between age and periodontal recession in premolars than in the other teeth could have resulted from their being less affected by periodontitis. However, the introduction of a correction factor for teeth extracted for periodontal disease did not change this pattern. Of the teeth now under investigation, maxillary premolars have been reported to have the highest extraction rate for periodontal reasons[18]. Canines, especially mandibular ones, had the lowest loss rate, but these teeth showed the weakest correlation between loss of periodontal attachment and age. Also, the fact that premolars originated from younger individuals than the other types of teeth could be a factor of importance for the stronger correlation between periodontal recession and age which was observed in these teeth. These findings, however, clearly demonstrate that tooth type should be taken into consideration in methods for age estimation. Separate formulae for each type of tooth should be developed or a factor correcting for tooth position included, as has been done by Maples[23].

The correlations between periodontal recession and age were rather weak in this study; 0.07 to 0.50 for Johanson's scores[9] and approximately the same for PMEAN. Johanson found an overall correlation with age of $r = 0.49$ for his scores, while Dalitz[8] reported a correlation of $r = 0.66$ for Gustafson's scores and 0.72 for his own scoring system. A correlation of $r = 0.49$ was found in a study of Burmese males[24]. Sounders[11], on the other hand, claimed no definite relationship between periodontal recession and age.

The rate of loss of periodontal fibres seems to be reduced in older individuals. The fact that the logarithmically transformed variables showed a stronger correlation with age lends support to this theory. This seems to contradict reported findings of a tendency for more rapid loss of periodontal attachment in older individuals[25]. An explanation may be that a number of teeth are lost because of severe periodontal destruction in relatively young subjects. Those teeth that survive into old age are not affected by periodontitis to the same extent, an assumption that may be supported by findings that the proportion of individuals with gingival pockets >4 mm is approximately the same in subjects between 30 and 40 years as in those above 60 years of age[26]. It is also supported by a large American sample, where it was found that the percentage of persons with pockets did not increase in the elderly[20]. However, active periodontal destruction could still proceed more rapidly in elderly individuals.

As it may be assumed that teeth extracted for periodontal reason might have lost more of their attachment than teeth unaffected by such a condition, a corrected PMEAN was calculated by dividing by 3 and creating a new variable PM (corrected PMEAN). This resulted in a stronger correlation between periodontal recession and age for some teeth, but a weaker correlation was unexpectedly found in other tooth types. An explanation may be that only the diagnosis of periodontitis made by clinician as reason for extraction was taken into account. It is reasonable to believe that a number of teeth extracted for reasons other than periodontal might in addition be affected by periodontitis. Thus this correction did seem to be justified.

The application of tooth age did not increase the correlation with periodontal recession. In a study by Boyle et al.[5] the eruption pattern did not influence the alveolar crest height, and this also indicates that the time of eruption is of minor importance. Thus calculation of tooth age seems unnecessary for age estimation from teeth. However, if a formula based on all teeth is used, tooth age values could be an alternative to tooth position values.

Partial correlation controlling for the effects of the sex and reason for extraction, resulted only in minor changes in the correlation between periodontal recession and age. Thus the Pearson correlations can be taken as a fairly accurate expression for this relationship.

The sex was not significantly correlated with PMEAN when applying partial correlation and controlling for the effect of age. However, in the multiple regression analysis the sex significantly contributed to the formula for age estimation for mandibular incisors. As the sign was negative and males coded 1 and females coded 0, this means that males had the same amount of periodontal destruction as females at a younger age. Thus, males tended to be more effected by periodontitis than females confirming previous reports[27,28]. A study of dry mandibles from South African blacks[29] failed to reveal any sex differences in tooth loss, which indicates that the observed differences in modern populations may be culturally related.

Unexpectedly, the reason for extraction was unimportant for PMEAN except in mandibular canines. Reason for extraction was denoted as 0 or 1 in teeth from deceased individuals, as 2 for periodontal disease, as 3 for caries and 4 for any other reason. Extraction for periodontal disease located in the middle of this scale is arbitrary and may have prevented a clear statistical result.

It was not possible to confirm a close association between degree of attrition and loss of periodontal attachment in the present modern material as contrasted with findings in archaeological materials[2,3,4]. So the theory of continuous eruption as a result of attrition cannot be confirmed in this contemporary population. Probably both processes occur with time, but the association may be more apparent in archaeological material where they may have been more pronounced and regular than in modern man. The present material indicates that factors other than attrition are much more important for the degree of periodontal recession.

Using multiple regression analyses, a formula for age estimation with one or more independent variables was developed for each type of tooth. Despite being stronger when more than one factor was included, the correlation was not as strong as when dental root translucency[30] or colour[12] was used as parameter for age estimation. Also, for some teeth the amount of dental cementum[31] seemed to be a better indicator of age than periodontal recession. The latter cannot therefore be recommended as sole basis for age estimation. This is particularly the case as the distribution of periodontal recession is skewed, because some individuals affected by periodontitis lose a substantial amount of their dental attachment at a relatively young age[10].

For premolars in particular, the correlations between age and periodontal recession were so strong that the latter might play a significant role in a multiple regression method for age estimation. This factor has also been utilised in previous methods[7,9,22].

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ACCURACY OF DENTAL REGISTRATIONS IN FORENSIC ODONTOLOGY AMONG DENTAL STUDENTS

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ABSTRACT

The registration of dental characteristics in forensic work is crucial to the identification procedure and because of this, standardised recordings of dental characteristics should be applied. In order to improve accuracy in identification it is important to evaluate the types of errors that are made during the different steps of the procedure. Attempting to identify the most common interindividual variations, twelve dental students made recordings on excised, macerated jaws at the Department of Forensic Medicine in Göteborg as a part of the course in Forensic Odontology. The most common error was incorrect judgement of the extent of single restorations. Furthermore, the students had difficulty in identifying premolars and molars, especially in the mandible, confusing the two groups of teeth. This study emphasises the importance of carefully re-examining the postmortem dental findings by an experienced forensic odontologist before comparing them with the antemortem data.

Keywords: Forensic odontology, dental registrations, dental students.

INTRODUCTION

The recording of dental characteristics during forensic work is crucial for the identification procedure. However, human remains subjected to forensic analysis are often mutilated and sometimes severely fragmented. Recordings may therefore be difficult to perform, especially if the jaws cannot be dissected. In traffic accidents, for example, jaws may be fractured and teeth lost, thereby reducing the number of teeth available for the identification procedure. Remnants of human tissue may become extremely fragile after fire and it is important that a forensic odontologist with the required skills be present to recognise important remains at the site of the accident. This way, damage to the fragments may be minimised and retrieval of the remains carried out as completely as possible.

In a forensic analysis it is important to consider that intra- and interindividual variations exist in all types of registrations. In order to improve the accuracy of chartings it is important to identify the types of errors that are made during the different steps of the identification process. Discrepancies in obtaiing data from charts have been reported by Hardy[1] who studied chart notes and found that a common registration error was a mix-up between the first and the second molars in the mandible. He stated that it can be difficult to distinguish between the molars when early extraction of the first molar has been performed.

One seldom finds a perfect match of ante- and postmortem records because dental surgeons may overlook structures or restorations while charting.[2,3] In earlier studies[4,5,6] considerable variations were found among specialists when asked to match "ante- and postmortem" radiographs from both dentate and edentulous individuals. In this study, we further identified common errors of dental registrations on deceased individuals.

MATERIAL AND METHODS

Twelve fourth year dental students made dental registrations on excised, macerated jaws in the mortuary (Department of Forensic Medicine, Goteborg) as a practical seminar during the course in forensic odontology. Five maxillae and five mandibles from deceased persons were included in the study. The observers were asked to register missing teeth, positions of teeth, attrition, periodontal condition, type and number of restorations and ante- or postmortem lost teeth. The observers formed their own criteria for the different parameters and no time was set for the procedure. The students' registrations were compared to those made by experienced forensic odontologists (HB & LR.)

RESULTS

The number of errors for the different observers is shown in Fig. 1. The mean number of errors was 16 (range 12 to 30) and the total number was 218. The different types of errors are shown in Fig. 2. The most common error (87) was incorrect registration of restorations and the second most common error (50) was confusion about the premolars and the molars in both maxilla and the mandible. Another common error (38) was mix-up between ante and postmortem lost teeth. Errors less frequently observed were: discoloured teeth and damage by fire registered as caries (23). "Other errors" (20) included carious lesions and fractured teeth not registered. In addition, all observers failed to register a diastema between premolars in one of the lower jaws. The number of errors for each case is shown in Fig. 3.

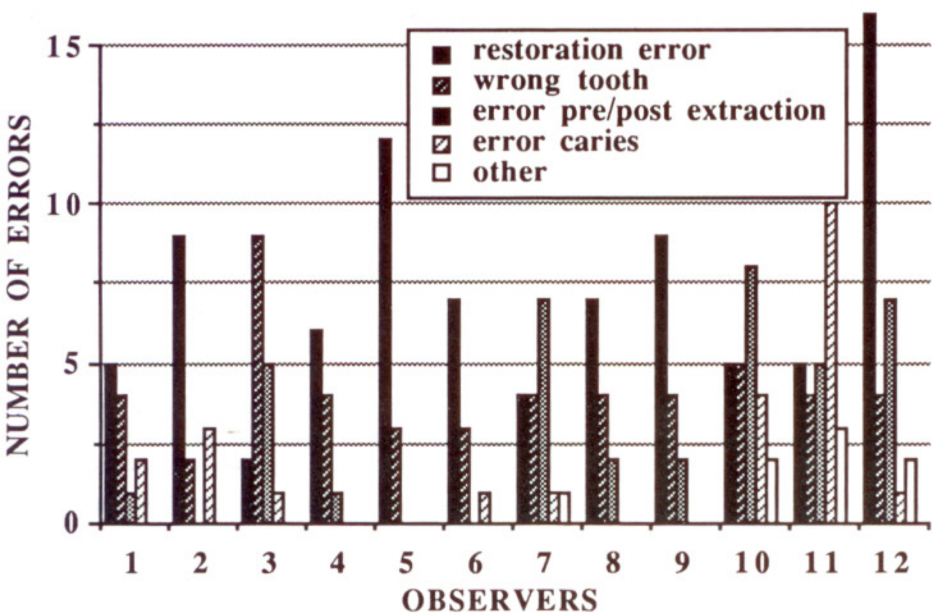

Fig. 1 The number of errors for the 12 observers.

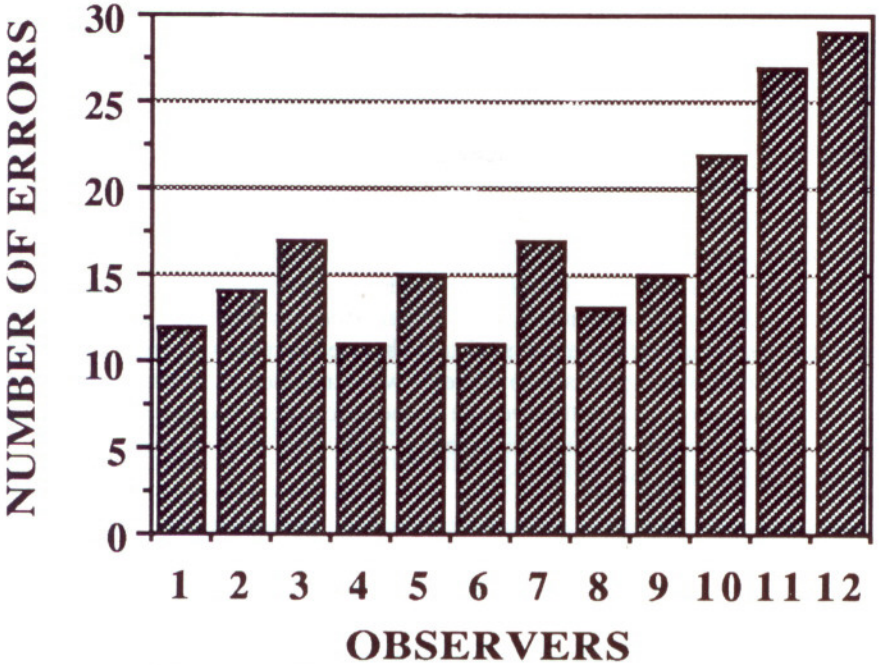

Fig. 2 The different types of errors among the 12 observers.

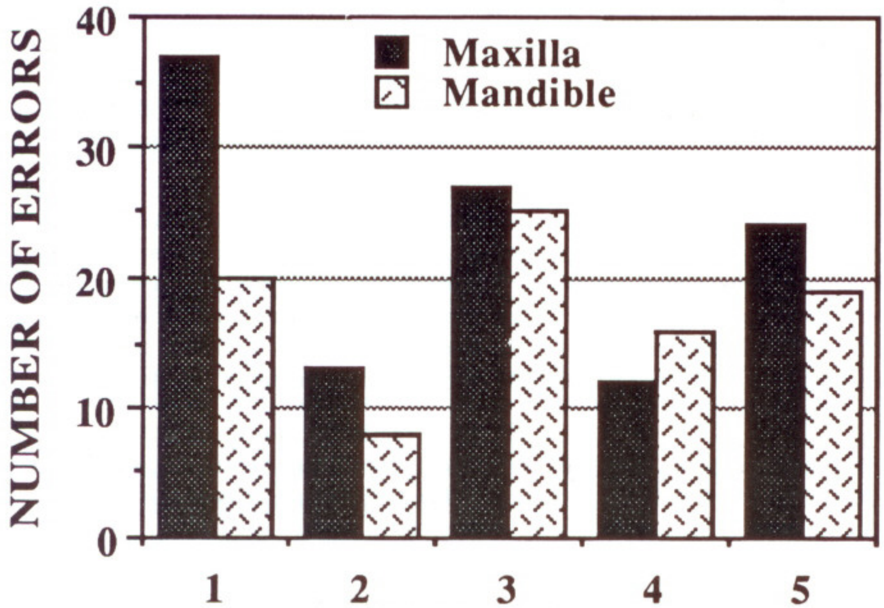

Fig. 3 The number of errors for each pair of jaws.

DISCUSSION

It is crucial in forensic work to have good access to the jaws by removing all soft tissue, especially cervically, where small restorations could otherwise easily be overlooked.[7] In addition optimal light is necessary during the charting.

In this study the jaws were freed from soft tissue and cleaned, in contrast to the routines in practical forensic work where the jaws are not usually dissected out. It is also more difficult to gain access to anatomical details, especially the posterior parts of the jaws when they have not been removed from the body. In spite of this the exercise was considered valid in order to complement previous similar studies[4,5]. One must remember that dental students are not fully qualified examiners, although in an earlier study on observer accuracy in combining ante- and postmortem radiographs, two students were included as observers and their performances were equal to the average by the specialists[5]. We therefore conclude that it is not only the training in a special field that is of importance for the accuracy of the outcome of the work.

Confusion about the extension of a filling from the occlusal surface onto a buccal or lingual surface may occur when charting.[8] It is our opinion that the concept of extension of a restoration can be quite variable because seven of the observers did not describe the extension of single amalgam fillings as the authors did. For example, several restorations were recorded as MOD instead of MODB or MODL. Similar findings were recorded in a study on the advantages of intraoral photography in forensic odontology.[9] However, in mass disaster situations, there are special recommendations for recording dental details including photography and radiography[10,11].

Thus, a variety of documentation will provide the forensic odontologist with as much information about the postmortem dental conditions for comparison with the antemortem chart data, as possible.

Tooth coloured restorations in premolars, canines and incisors were also missed, especially when they were placed buccally. In order to avoid misreadings during routine forensic work we therefore would like to suggest re-examination of all registrations. Radiographs may provide additional information about the presence of tooth coloured restorations but it can be difficult to determine the type of material used although radiographs can reveal information about the extension of a restoration.[12]

This study confirms the results described by Hardy[1] on the mix-up between molars, especially when early extractions have been performed, causing mesial movement of the second molar. This was evident in both the maxilla and the mandible. Furthermore, this study shows that the observers who made mistakes on the tooth numbering also seemed unable to differentiate between teeth lost ante- and postmortem. It might be difficult for the students to evaluate the degree of bone healing after extraction due to their limited clinical experience. However, the results were somewhat unexpected since nine of the 12 observers made these errors.

Dental caries was misinterpreted 23 times, but one observer made 10 errors while four made none. This could have several explanations, such as discolouration of the teeth due to exposure to high temperatures in fires. Further, no probing facilities were available and no radiographs were taken during the registration. The high number of errors for one of the maxillae might be explained by the fact that this particular jaw was more damaged than the other jaws after its involvement in a fire.

When interpreting the results from this study it is important to consider that some teeth had several characteristics and many single rooted teeth were missing. This caused problems for the students because they were not used to observing bony remains, while some of the students seemed to have difficulties in defining certain dental characteristics.

The results from this study will serve as an aid when planning and preparing undergraduate teaching for dental students and forensic continuing educational courses. It is important to provide the students with radiographs revealing additional information about the postmortem dental characteristics. Further studies of the accuracy of dental registrations by dental students during their course in forensic odontology[13] are indicated and should be beneficial.

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TEN YEARS OF FORENSIC ODONTOLOGY: A REPORT FROM THE DEPARTMENT OF FORENSIC ODONTOLOGY, STOCKHOLM, SWEDEN

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ABSTRACT

The practical activities of the Department of Forensic Odontology at the National Board for Forensic Medicine in Stockholm, Sweden, have been reviewed over a ten year period (1980-1989). The number of cases has increased from 72 in 1980 to 278 in 1989, and a total of 1402 tasks have been carried out. Seventy-five per cent of the cases have concerned identification of single individuals, 14% have involved the National Register of Missing Persons with the remaining cases being age determination (34), bite marks (27), oral examination after criminal assault (69), examination of skeletal remains, dentures, restorative materials (33) and written reports to be presented at court (159).

Keywords: Forensic dentistry, annual report.

INTRODUCTION

Forensic odontology has only recently emerged from having been mostly a practical discipline managed by general practitioners into becoming academic and linked to universities. However, only a few countries so far have departments for forensic odontology, and full time academic positions dedicated to the discipline are rare.

In Sweden two forensic odontology departments were instituted in 1970, one at the National Board (formerly Institute) of Forensic Medicine to handle the practical aspects and one at the Karolinska Institutet to take care of the academic aspects of the discipline. Both departments have one and the same staff, being one full-time forensic odontologist with research and educational qualifications and training (DDS/BDS and a PhD needed), one half-time research assistant and secretarial facilities.

All practical forensic odontology is carried out by request from any of the 121 police districts and is canalized via one of the six districts of forensic medicine with institutes in Stockholm, Uppsala, Linkoping, Umea, Gothenburg and Lund. The first three mentioned institutes are served by the Department of Forensic Odontology in Stockholm and the three others on a freelance basis by dentists belonging to the academic staff at the dental schools situated in the same cities.

The number of commissions has evolved over the 20-year existence of organisation from a few cases per year to about one case per working day. Most cases in the country are handled by the Stockholm unit, but a few (around 20 per unit) are dealt with at the three other places (i.e. Umea, Gothenburg and Lund). The Department is also responsible for managing the dental records of the National Register of Missing Persons.

In this essay we report on the work carried out at the Department of Forensic Odontology at the National Board of Forensic Medicine in Stockholm, Sweden, during the last ten years.

MATERIAL AND METHODS

Since the start of the Department in 1970 all cases have been recorded in a diary and on that basis all cases from 1980 to 1989 were studied. Generally adequate information was obtained from the diary, but some records had to be delved into for more detailed information. A series of variables was studied and concerned mostly individual persons, dead or alive, described by sex and age. The problems to be solved were either unknown identity, analysis of bite marks, age determination, examination of living persons after assaults, and others. The outcome, positive or negative, of the task was also described, and the police district which had given the commission recorded.

RESULTS

The number of cases has steadily increased over the years from 72 in 1980 to 278 in 1989 (Fig. 1) with a total of 1402 cases over the ten-year period. Of the 1353 cases that concerned individual persons, alive or dead, 71.9% were men and the remaining 28.1% women. In 49 cases (3.5%) the sex was unknown to us or the case concerned examination of a non-human object. The age distribution of the individuals ranged from birth to 97 years (Fig. 2), with the mean age 46.5 years (±19.4).

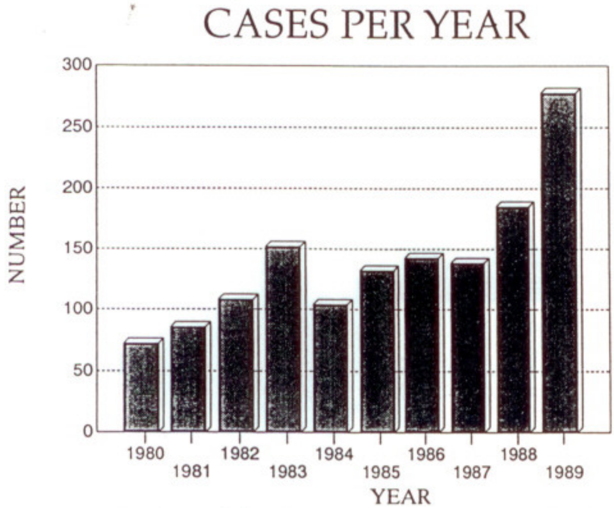

Fig. 1 Number of forensic odontology cases 1980-1989.

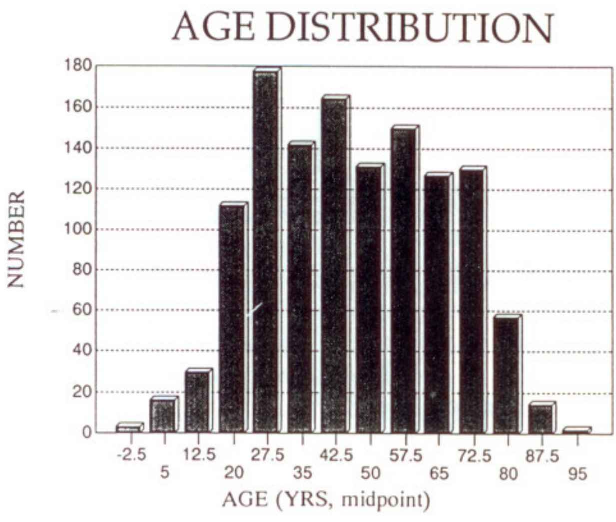

Fig. 2 Age distribution of 1255 individuals subjected to some kind of forensic odontologic examination during the years 1980-1989.

Fig. 3 demonstrates the police district origin of the commissions. Most police districts asking for help were those of the Greater Stockholm area and those belonging to the forensic medicine districts of Uppsala and Linkoping. A few cases from districts outside our ordinary jurisdiction were also handled (Umea, Gothenburg and Lund) with 18, 25 and 21 cases respectively). Cases handled within the National Disaster Victim Identification (DVI) Team and by request from INTERPOL are shown separately.

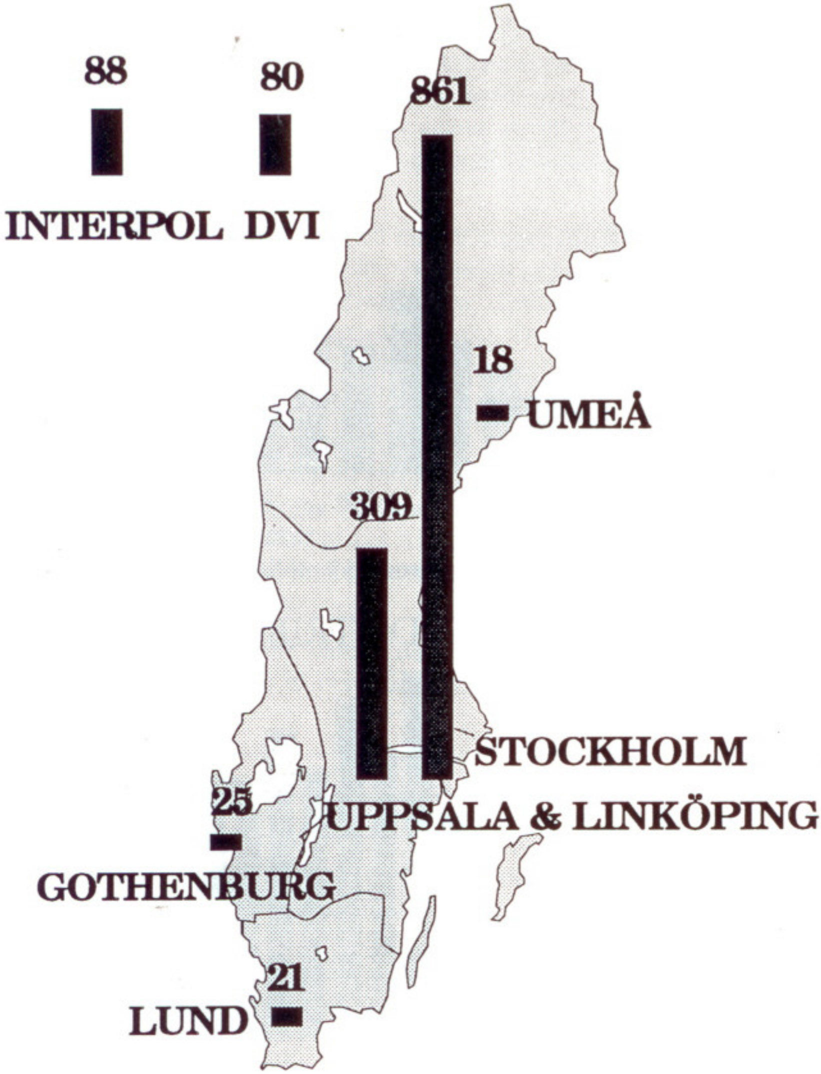

Fig. 3 The geographic distribution of cases handled by the Department of Forensic Odontology in Stockholm.

Most cases (1048) were about identification of unknown bodies at, or some days after death. Of these 785 (74.9%) were successfully identified by dental means and 34 (3.2%) by medical means. 225 cases (21.5%) were identified by the police (mostly by finger prints) before dental identification had been carried out and the remaining four cases (0.4%) were still unsolved at the time of reporting (Fig. 4).

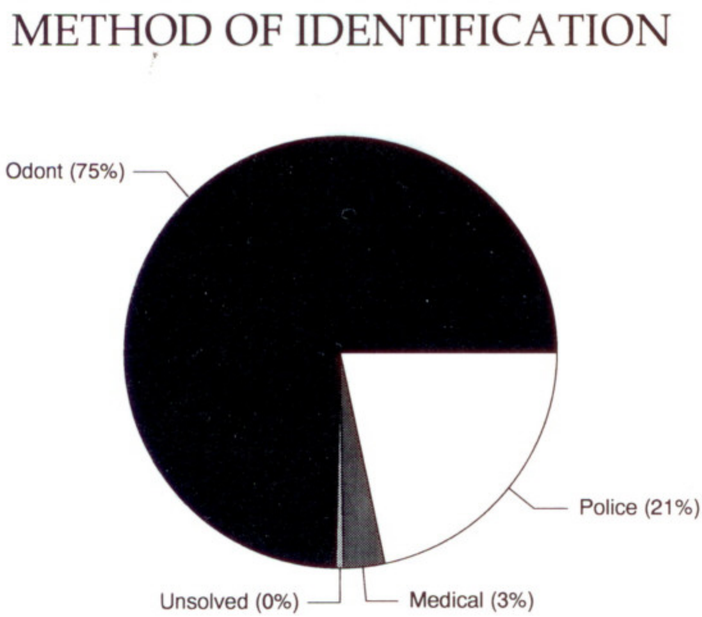

Fig. 4 Methods used for the identification of 1048 bodies whose identity were unknown at, or some days after, death.

Of the 785 cases that were identified by dental means, both dental records and dental radiographs were available in 551 cases (70.2%). Radiographs only were available in 91 (11.6%) and written records only in 51 (6.5%) cases. Seventeen cases also had oral photographs, dental casts or descriptions from dental laboratories. The remaining 92 cases (11.7%) had some medical records, medical radiographs or other material for comparison.

Of the 1048 cases to be identified 387 (36.9%) were decomposed to a degree not allowing visual recognition, 204 (19.5%) were affected by fire, 219 (20.9%) were badly mutilated after traffic accidents, shot in the face, etc. and 169 (16.1%) were decomposed after a long immersion in water. Thirty-one (3.0%) cases were completely skeletonised and the remaining 38 (3.6%) cases were intact (Fig. 5).

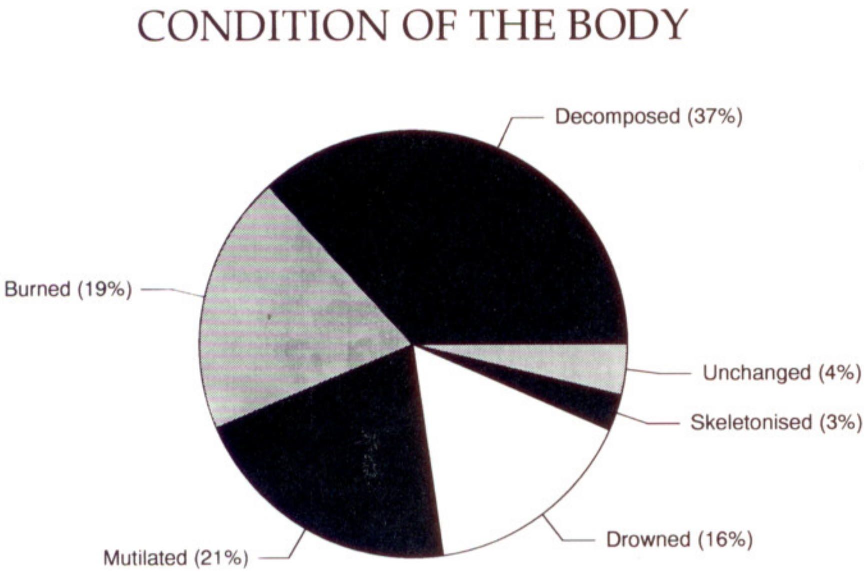

Fig. 5 Conditions of the bodies subjected to dental identification.

Most of the 387 cases found in a decomposed state were elderly individuals found in their homes some weeks, months, or years after death. They had a significantly higher age than the individuals in the other groups; 59.0 years compared with 46.5 years for the whole sample. The average age of the badly mutilated was significantly lower, 37.0 years, than that of all other groups excepting the intact group ($p<0.05$, one way ANOVA followed by Tukey's honestly significant difference test). These latter two groups consisted mostly of individuals killed in traffic accidents or who had committed suicide.

Of the individuals subjected to dental identification or examination, 806 cases had at least one tooth in any jaw, 143 were edentulous, 122 had teeth in only one jaw and in 55 cases there were only fragments of jaws or teeth left. Full or partial dentures were worn by 167 cases out of which 32 (19.1%) were marked with the personal identification number.

Thirty-four cases concerned age determination by means of the teeth. Of these 26 were children where age determination was carried out by methods using comparisons with developmental charts.[1] The remaining eight cases were predominantly deceased adult individuals where Gustafson's[2] or Johanson's[3] methods were used.

Twenty-seven cases concerned analysis of bite marks, 18 in skin and nine in foodstuffs or other inanimate material.

Oral examination of individuals subjected to criminal assaults were done in 18 living and 51 deceased cases.

In 1983 the National Register for Missing Persons were instituted and up to 1989 191 dental records have been registered and systemised, totalling 13.6% of all cases handled at the Department. Since then 50 unknown bodies have been identified by means of the computerised dental database of missing persons.

A few remaining cases (33) have concerned examinations of historical skeletal remains, dentures and dental restorative materials.

Written reports to be presented at court have been produced in 159 assault, age determination and bite-mark cases.

DISCUSSION

This report describes how practical forensic odontology has developed in a medium-sized capital of a highly developed and organised country over the last 10 years.

After a build-up period, when the contribution of forensic odontology to forensic medicine and to the police was publicised the practical work started to consolidate in about 1980. It took some 10 years to make authorities aware of the special knowledge and skills forensic odontology has to offer, and to standardise procedures. Over this period, and since then, forensic odontology lectures of one to two hours are included in the undergraduate course in forensic medicine at the medical schools and about ten hours during the courses for investigative police detectives at the police schools. Informative articles have been published in police journals.

In spite of the foregoing however, the build-up period still continues because the increasing number of cases has not yet levelled out. Tentative figures for 1990 and 1991 are 254 and 314 respectively. Although it is not possible to predict the optimum number of cases, the figure appears to be as it is at present, around 300 cases per year.

The majority of commissions have concerned identification of unknown dead persons, about 200 cases per year in recent times. It is policy to avoid visual recognition by relatives and friends since this procedure has been shown to give erroneous results in too many cases. It is also much more reliable in the case of decomposed bodies for the identification to be objective and without emotional interference. Most accident cases or deaths involving single persons have been mere confirmations of police identifications. In almost all these cases dental records have been the means of confirmation only. Only rarely has provisional identification been refuted. Skeletons or heavily decomposed bodies of persons who had been missing over a longer period were often first identified by means of the computerised dental database of missing persons. During the five mass disasters that occurred over this period, the task was primarly to match a defined number of missing persons with the deceased.

The 26 cases of age determination of children all concerned adopted or immigrant children from developing countries with uncertain birth records. Although the number of cases is low we have a feeling that this kind of task is decreasing in frequency. Age determination of adults have all been on the dead and were carried out as part of otherwise difficult identification processes in order to limit possible candidates.

The number of bite mark analyses appears to be low in comparison with reports from other countries[4-7]. The reason for this is obscure, but may depend on lack of awareness of our referral sources. Several cases however have been abandoned at preliminary evaluation because of indistinct marks and have therefore not been recorded.

It seems to us that a highly developed country has a serious need of at least one full-time forensic odontologist to head and co-ordinate the practical odontological activities in the country. Among his responsibilities should be also to arrange for a sufficient number of properly trained dentists to assist at mass disasters, and to ensure an adequate expertise and quality of forensic odontology to serve the country's needs.

ACKNOWLEDGEMENTS

We wish to thank our predecessors at the Department, Professor Karl-Oskar Frykholm (1970-1975), Professor Gunnar Johanson (1975-1989) and Dr. Leif Kullman (1989-1990), who have headed the department at various times and done most of the practical work reported in this study.

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THE ORIGINS AND DEVELOPMENT OF FDI, INTERPOL AND IOFOS: INTERNATIONAL CO-OPERATION IN IDENTIFICATION

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"None of us should ever forget our roots" (Ferdinand Strom)[1]

FEDERATION DENTAIRE INTERNATIONALE

In 1900 Dr Charles Godon (1854-1913), Dean of l'Ecole Dentaire de Paris, attended the Third International Dental Congress being held in the French capital. Having long wanted to see the establishment of an international organisation of dentists, he discussed the idea with his colleagues and succeeded in interesting eight leading dentists from different countries. They met on 15 August 1900, constituting themselves the first executive council of a new international dental federation, the FDI, with Godon as its first president.[2] After the International Committee of the Red Cross FDI is the oldest international organisation in public health.

Ninety years later 85 countries were members of FDI and every year dentists from all over the world meet during the annual world congress; a biannual newsletter is produced which is its official publication.

The FDI supports a variety of subgroups, one of which in the past was the Working Group in Forensic Odontology. During the 1970 Annual Congress in Bucharest, Romania, the two digit system of recording teeth was originated and destined to find wide acceptance, although there are still about 30 tooth notation systems in use and the FDI scheme is not yet universally accepted. Dr S Keiser-Nielsen was chair of the WG/FO at the time (1968-1972) and was instrumental in establishing the tooth notation system and having it approved. He was also on the FDI Commission on Dental Research, chair of the FDI Special Committee on Uniform Recording and co-founder in 1973 of IOFOS. He was later its president between 1978 and 1981.

INTERPOL

Shortly after World War I the Dutchman M.C. van Houten took up the idea of international co-operation between the major police institutions of the world. It was only in 1923 however that Police President/Chief Schober of Vienna succeeded in getting the movement off the ground. He convened an International Police Congress in Vienna which, among other things, passed the historic resolution to transform the Congress into a permanent institution under the name of the International Criminal Investigation Commission with headquarters in Vienna. It had the following aims:

1. to guarantee and foster mutual assistance to the greatest possible extent of all security services within the bounds of national laws and
2. to provide for the creation and organisation of institutions suitable for the successful fight against organised crime.

At the end of World War II the Commission was disbanded and in 1946 the Belgian Police in Brussels called for a conference to resurrect the ICPC. This took place in Vienna on the 25th anniversary, and at the same place, of its founding. The following decisions were taken:

1. to redefine and state the aims of the commission more precisely, and
2. to rename the Commission the International Criminal Police Organisation.

A milestone in the evolution of INTERPOL, as it became known, was the Police Congress in Monaco in 1914 which was attended by police and legal officers from 14 states while in 1955 the 50th member organisation joined ICPO which now has 125 member organisations. INTERPOL is a corporate body acknowledged legally by the Economic and Social Commission of the United Nations as an international organisation.[3] One of the first actions to be taken to realise its aims was immediately to set up fast and widespread communication between its members. It now maintains a research department at the General Secretariat which aims to collect and disseminate recent scientific developments, supports its own research in criminal investigation and recommends organisational and equipment improvements to its affiliated national police forces. An example is its set of four different writs on differently coloured paper.

1. Writ of attachment - red.
2. Writ to obtain information - blue.
3. Preventive writ - green, and
4. Writ to identify unknown bodies - black.

The fourth is of interest to forensic odontology.

INTERNATIONAL ORGANISATION FOR FORENSIC ODONTO-STOMATOLOGY

Before introducing IOFOS a short biographical sketch of the reputed founder of forensic odontology is indicated. Dr Oscar Amoedo was born in Cuba on 10 November 1863 and studied at the University of Havana. He then went to the New York Dental College, returning to work in Cuba in 1888. In 1889 he was sent as a delegate to the International Dental Congress in Paris where professional life and activity appealed to him and he decided to stay. He became a clinical instructor at the Ecole Odontotechnique de Paris in 1890, an assistant professor in 1891 and a full professor in 1895 where he served without payment in this institution for 15 years until 1905. He wrote more than 120 articles on all aspects of dental practice and science but became particularly renowned for his publications in forensic odontology, so much so that he became known as its founder.

Oscar Amoedo was an extrovert and a teacher in the true sense of the word. He became an active member of 14 learned dental and medical societies. Speaking Spanish, French and English fluently he came to participate in 57 professional congresses all over the western world, his last documented participation being in 1936 when he was 72 years old. He died at his home on 25 September 1945.[4]

It can be said that IOFOS was the culmination of the international work of Amoedo. In the spring of 1972 two French doctors, Francois Garlopeau, son-in-law of the eminent forensic pathologist Professor Piedelievre, and Jean Payen, working at L'Hopital de la Pitie in Paris in the Department of Pathology and Stomatology headed by Professor Duchaume, saw the need to establish an international society for forensic stomatology. They sought a dentally qualified third partner and found him in Malmo, Sweden. He was Gosta Gustafson, Professor of Oral Histopathology at the Odontological Faculty, University of Lund, Sweden, with whom Jean Payen had worked in Malmo. Gustafson was invited to participate in forming an international society for forensic stomatology and to become its first chair. The two from l'Hopital de la Pitie invited Gustafson to Paris in June 1972 and discussions, which included Piedelievre who was very interested in the project, were initiated. After some weeks they met again at the Hopital de la Pitie and a few days later they convened over dinner at the Eiffel Tower and made final arrangements prior to founding the Association.

Gustafson agreed to take the chair while Garlopeau became secretary and Payen treasurer. The name of the society was to be the International Association for Forensic Stomatology, proposed by Garlopeau and Payen but Gustafson suggested that Odontology be added.[5] This was probably because of Gustafson's book "Forensic Odontology" which had become well known internationally and which, according to the Oxford Dictionary, was the first occasion in which the words forensic and odontology were combined. The society thus became known as the International Society for Forensic Odonto-Stomatology. "Society" was later replaced by "Association".

Gustafson's many international contacts, both by letter and at meetings attracted members to the new Association. Membership was to be open to anyone who was interested in the discipline and not only dentists but medical forensic scientists and police in many countries including USA, Australia and the Far East joined. The prominent Professor Keith Simpson of Guy's Hospital University of London was a supporter and had written the foreword to Gustafson's book; as a result further members were attracted. A proposal at this time that non-dentists should not have to pay fees was not accepted and it was feared that many valuable connections with other disciplines were lost.

The Association was now well and truly growing and at its first meeting in Zurich in 1975 it had reached sizeable proportions. Unfortunately Francois Garlopeau died not long after the initial meetings and could not enjoy the success of his initiative. Strangely, all records of the early years disappeared with his death.

The initial executive committee thus consisted of the following:
President: Gosta Gustafson (Malmo, Sweden)
First Vice-president: Lowell Levine (New York, USA)
Second Vice-president: Kazuo Suzuki (Tokyo, Japan)
Secretary-general: Francois Garlopeau (Paris, France)
Assistant Secretary-general: Robert Weill (Paris, France)
Treasurer: Jean Payen (Paris, France)
and the Secretariat address was 4 Rue Soufflot, Paris.

THE JOURNAL OF FORENSIC ODONTO-STOMATOLOGY

The Journal of Forensic Odonto-Stomatology was established as an independent publication in 1982 in South Africa. In 1987 it became the official publication of IOFOS, is now based in Australia with Associate Professor Cyril Thomas as its editor-in-chief. Its reputation is spreading and it has attracted material internationally both from researchers and practising forensic scientists. As the voice of IOFOS it is hoped it will reflect the activities of its members and so lead to forensic odontology, as an independent discipline, taking its rightful place in the forensic sciences.[6]

COMMUNICATION AND COLLABORATION

Forensic odontology has grown slowly in the USA with the first dentist joining the American Academy of Forensic Sciences (AAFS) in 1948 and the second in 1966, a "time tunnel" of about 18 years.[7] In 1992 however a very successful joint meeting between American Society of Forensic Odontology and British Association of Forensic Odontology at the American Association of Forensic Sciences meeting in New Orleans was held. This holds rich promise for the future.

An area of less promise at the moment is links with INTERPOL and the FDI. By no means all countries are members of INTERPOL, and neither is IOFOS. IOFOS wishes to join the FDI. The present president regards as valuable a presence on the Commission on the Defence Forces Dental Services and views as useful a strategic avenue in the Vice-chair of the Commission Dr Jean-Gabriel Schneider who is a member of both FDI and IOFOS. He feels it is not necessary to reactivate the WG-FO of the FDI and believed there are adequate lines of communication between IOFOS and FDI. These are:

Dr Ian Hill, UK (President of IOFOS 1981-84)
Dr Kenneth A Brown, Australia (President of IOFOS 1984-90)
Dr Claude Lavaste, France
Dr Hakan Mornstadt, Sweden (President of Swedish Society of Forensic Odontology)
Professor Pertti Sainio, Finland (President of Finnish Association of Forensic Odonto-Stomatology)
Dr Norman Sperber, USA
Brig FE Ashenhurst, UK
Rear Admiral D Coppock, UK
Captain TJC Hall, UK
Air Commander JA Martin, UK
Air Commander JA Quant, UK
Lt Col F Watson, UK
The Standing Activity on FO is represented by Dr H Kessler, USA.

Contact between the above representatives and consultants must be encouraged and the benefits to both the FDI and IOFOS will certainly increase.

COMPUTER ASSISTED DISASTER VICTIM IDENTIFICATION

Electronically assisted systems (EASY) are essential components of DVI procedures and have already proved to be very useful to all member countries of INTERPOL. Up to the present many teams of workers have produced computer programmes, among which are OD (Sweden), VISTA (in memoriam Ove Sakshaug, Norway), RITSYS (Dutch), FOUR-QUADRANT-METHOD (Eva Maria Hagen, Dusseldorf in collaboration with the German Federal Bureau of Crime Investigation - BKA, Wiesbaden), IDENTIFY (Hannu Makela, Tikkakoski, Finnish Air Force), ODONTID (Forensic Odontology Unit, Adelaide, Australia), IDENTIC (Katherine Arneman and Rob Wilkins, NSW Forensic Dental Unit, Sydney, Australia), CAPMI (Lewis Lorton, US Army Institute of Dental Research), TOOTHPICS (Class One Limited, Tempe, Arizona, USA), IDENTIFY and SONAR PROFESSIONAL (Joint US/Finnish Project). This diversity of systems need not be a barrier to successful DVI work. Interaction between the different automated or semi-automated national databases will shorten the time needed to collect the ante-mortem data and universal use of the INTERPOL DVI forms is important. The ASFO/BAFO meeting in New Orleans has confirmed this.

CONCLUSIONS

After the International committee of the Red Cross the FDI is the oldest international organisation in public health, having been created in 1900. On the other hand the ICPO, or INTERPOL came into being in Monaco in 1914 at the International Police Congress attended by police and legal officers from 14 states.

IOFOS was founded in Paris in 1972 by Garlopeau, Payen and Gustafson, and after its first meeting in Zurich has grown steadily and Gosta Gustafson is still able to enjoy the fruits of that earlier initiative of his and his French colleagues.

Contacts between IOFOS and FDI are important, must be nurtured and extended and all avenues through colleagues, personal friends, diplomats and officers in both organisations must be utilised. Forensic odontology in the USA, which has grown slowly, must also now take its place in these world bodies because it has much to offer.

One of the greatest benefits IOFOS has to offer is its opportunity for international co-operation, establishing friendships and exchanging information and experiences. Meetings are held only every three years, and among attendees some faces are new, some only transient, others are familiar, making their regular attendance while others will not be present and will be missed. Whomever attends however is assured of a warm welcome.[8] IOFOS invites all who are able, to attend the combined 13th Triennial meeting of the International Association of Forensic Sciences and International Organisation of Forensic Odonto-Stomatology in Dusseldorf, Germany, 22-28 August 1993.

We need collaboration, not isolation. We need co-ordination.

"The only guide to the future is the study of the past."[2]

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