

Chapter 5

Craniofacial Superimposition: State of the Art



5.1 Introduction

A complete analysis of the scientific literature concerning cases resolved using CFS was conducted to ascertain the prevalence of CFS use among forensic scientists. However, since many experts working with CFS may not have published their activity in the field, a survey was launched among anthropologists by the “Methodologies and Protocols of Forensic Identification by Craniofacial Superimposition” (MEPROCS) project, a project which aimed to propose a common EU framework to allow the extensive application of the CFS technique in practical forensic identification scenarios, commonly tackled by the European scientific police units.

The questionnaire was prepared by the European Center for Soft Computing (Spain), based on the requirements and scientific experience of forensic investigators from the University of Granada (Spain), Coimbra University (Portugal), Guardia Civil (Spain), and Israel Police. This survey was sent to approximately 600 forensic scientists worldwide, over a period of 3 months. The data was provided by forensic investigators from universities and law enforcement agencies from 32 countries in North, Central, and South America; Europe; Asia; and Africa. A total of 97 responses were received. Of these, 45 investigators answered that they have used CFS as a method of identification in diverse investigations.

The survey was composed of 16 questions addressing issues related to the number of cases undertaken in the last 30 years; classified according to different identification scenarios (mass graves, terrorism, missing persons, and common graves); the number of hours employed conducting CFS; identification results; whether the results were presented in court; the materials, tools, and techniques used; and the main problems faced in the application of CFS.

Of the 97 responses, 56% were positive, that is, the investigator reported using CFS on a regular basis or having used CFS in the past. The following report addresses only the positive responses.

5.2 Use of the Technique

From the MEPROCS survey, a total of 3854 cases of CFS were reported: of these, 2744 (71.2%) were presented in a court of law and 1246 (32.3%) of them resulted in a positive identification. Most cases (2489) were not classified by the responders into any of the categories suggested in the survey. The following sections are devoted to an in-depth analysis of participant responses, according to the main issues asked. The data was provided by forensic investigators from universities and law enforcement agencies worldwide.

Over 50% of the investigators have implemented CFS in only a small number instances (1–10 cases over a period of 10 years) mostly in missing persons or homicide investigations, while the remaining respondents reported a larger caseload (more than 20 cases).

5.2.1 Identification Scenarios and Nature of the Investigation

According to the identification scenario, we have defined a classification system based on the number of candidates to be identified and the number of possible matches: one candidate, an open list, or a closed list of candidates. The open list is considered an event that results in the death of an undetermined number of unknown individuals, for whom no data or records are available. Closed lists, on the other hand, are those in which death has occurred to a known group of identifiable people. The first category of this classification is the presumed identity of only one candidate (PIOI). The second and third categories are either the presumed identity of an individual within a closed list of possible candidates, PICL, or the unknown identity of an individual within a closed list of possible candidates, UICL. The last category is the unknown identity of an individual within an open list (UIOL). Finally, CNC denotes those cases not classified by the responders.

Table 5.1 shows the classification of the total number of CFS cases reported by the participants in the survey according to the nature of the investigation. The most common scenario is the presumed identity of only one individual candidate (545 cases). The two different categories considering a closed list include 670 cases, while the open list was applied in at least 150 cases.

All cases were further classified based on the nature of the investigation addressed. We have distinguished the following four:

- *Mass disasters* are defined as natural or man-made events, which cause death or injuries to large numbers of individuals. These include natural disasters caused by floods, climate and geophysical phenomena and epidemics or pandemics, and man-made disasters, caused by man's actions, intentional or otherwise, such as, wars, civil disasters, or accidents.
- *Terrorism* can be defined as a human activity designed to cause harm, using premeditated violence with political or religious purposes.

Table 5.1 Use of CFS reported by 45 investigators

Scenario ^a	Positive identification	Exclusion	Undetermined	Not classified	Total
PIOI	451 (11.7%)	33 (0.9%)	61 (1.6%)	–	545 (14.1%)
PICL	309 (8.0%)	4 (0.1%)	19 (0.5%)	–	332 (8.6%)
UICL	336 (8.7)	–	2 (0.1%)	–	338 (8.8%)
UIOL	150 (3.9%)	–	–	–	150 (3.9%)
CNC	–	–	–	2489 (64.6%)	2489 (64.6%)
Total	1246 (32.3%)	37 (1.0%)	82 (2.1%)	2489(64.6%)	3854(100.0%)

^aScenario abbreviations: *PIOI* presumed identity of only one individual candidate, *PICL* presumed identity of an individual within a closed list of possible candidates, *UICL* unknown identity of an individual within a closed list of possible candidates, *UIOL* unknown identity of an individual within an open list, *CNC* cases not classified by the responders

Table 5.2 Classification results obtained in the survey according to the nature of the investigation

Nature of the investigation	Cases
Terrorist attack	15 (0.4%)
Missing persons	458 (11.9%)
Mass casualty	130 (3.4%)
Mass grave	87 (2.2%)
Other	3164 (82.1%)
Total	3854 (100.0%)

- *Missing persons*, in accordance with the RCIC (Red Cross International Committee), are those persons about whom their families have no news of and/or who, on the basis of reliable information, have been reported missing as a result of an armed conflict, international or noninternational, cause of internal violence, internal disturbances, or any other situation that might require the intervention of a neutral and independent public authority or when bodies lack information for identification, pursuant a medico-legal investigation of deceased person.
- *Mass graves* are places where an undetermined number of individuals are buried as a consequence of war, guerrilla warfare, or as a result of mass disasters. Often, the exhumation and study of skeletal remains from mass graves involves a long and costly set of procedures. A number of protocols have been suggested; mostly modified from the UN Manual on the effective prevention and investigation of extralegal, arbitrary, and summary executions (Pesce Delfino et al.1993), in which five different phases for the study of skeletal remains are suggested: preliminary investigations, exhumation research, forensic study, final report, and final destination of skeletal remains (Ibáñez et al.2009b).

Table 5.2 summarizes the responses according to the scenario in which CFS was applied. Unfortunately, most of the survey participants (82.1%) did not classify their cases.

Table 5.3 CFS cases grouped by country

Continent/country	Cases	Percentage
<i>Central and North America</i>	147	3.8
Mexico	105	2.7
USA	42	1.1
<i>South America</i>	1164	30.3
Brazil	6	0.2
Chile	2	0.1
Peru	980	25.4
Uruguay	176	4.6
<i>Asia</i>	2367	61.4
China	600	15.6
Japan	15	0.4
Jordan	5	0.1
India	1471	38.2
Russia	217	5.6
Turkey	58	1.5
United Arab Emirates	1	0.0
<i>Europe</i>	176	4.6
Spain	31	0.8
Denmark	10	0.3
Italy	20	0.5
Lithuania	80	2.1
Netherland	8	0.2
UK	7	0.2
Romania	20	0.5
Total cases	3854	100.1

5.2.2 Geographical Distribution

The global distribution of CFS identification cases between the different continents and countries is summarized in Table 5.3. India is the country in which most cases have been reported (1471), followed by Peru (980).

5.3 Methods and Tools

The investigators were asked to report on the method (manual, semiautomatic, or fully automatic) and type of CFS technique used, as well as the source of material (photograph, video image, or digital) for superimposition. Table 5.4 presents the distribution of the various techniques reported.

The tools required during the implementation of the technique are presented in Table 5.5.

Table 5.4 Distribution of reported techniques

	Photographic superimposition	Video superimposition	Computer assisted superimposition	Total responses
Manual	20	3	8	31
Semiautomatic	10	3	5	18
Automatic	11	1	2	14
Total	41	7	15	63

Table 5.5 Tools implemented in technique

Response	Chart	Percentage	Count
X-rays		12	4
CTs		12	4
3D Scanner		12	4
Video system		15	6
Skull bench		15	5
Photoshop		61	21
Others		39	13
	Total responses		34

Other responses included software such as Photomodeler, Freeform Modeling System, Powerpoint, Geomagic, and 3Dmax. Hardware used included Phantom[®] haptic devices, photographic cameras, and various types of scanners.

Tables 5.4 and 5.5 appear to present some inconsistencies. These can be explained by the lack of proper differentiation between the three CFS methods (photo, video, and computer). While only 14 of the investigators answered that they used computer-assisted superimposition, at least 20 of them reported that they used computer software (PhotoshopTM) to perform the superimposition.

These types of responses are expected as the scientific literature on the subject does not make a clear differentiation between the three categories. Similarly, there is also an inconsistency regarding the modality (manual, semiautomatic, automatic). For instance, 11 investigators responded that they utilized automatic photographic superimposition, when in fact to our knowledge, there is not a single automatic method or system of photographic superimposition.

5.3.1 Landmarks

Finally, the anthropological landmarks were addressed. The investigator responses regarding the landmarks utilized are presented in Table 5.6.

Other landmarks included general shape of the skull, contour of the face and skull vault, orbital measurements, orbital shape, eye width, Whitnall’s tubercle, chin lip fold, nasal outline (including asymmetry), tragus, position of auditory meatus, position of lips, dentition, chin, and mandibular angles.

Table 5.6 Landmarks used

Response	Frequency	Count
Glabella	38%	11
Nasion	38%	11
Rhinion	17%	5
Nasospinale-Subnasale	28%	8
Alare-Alare	31%	9
Subspinale-Superior labial sulcus	24%	7
Prosthion-Upper lip border (Labiale superius)	34%	10
Infradentale superius-Lower lip border	17%	5
Incisor superius-Stomion	10%	3
Supramentale-Labiomentale	14%	4
Gonion	38%	11
Zygion	31%	9
Orbitale-Infraorbital	17%	5
Supraorbital	10%	3
Porion	17%	5
Supraglenoide	10%	3
Dacryon-Endocanthion	34%	10
Gnathion-Menton	21%	6
Gnathion	38%	11
Pogonion-Mental	14%	4
Pogonion	14%	4
Prosthion	24%	7
Menton	7%	2
Ectoconchion	38%	11
Frontozygomatic suture-Ectocanthion	21%	6
Other	62%	18

5.3.2 Literature Review

The statistics obtained in the survey were similar to the data found in the literature.

Table 5.7 presents an analysis of the manuscripts reporting case studies solved using CFS. All of the papers reviewed were classified according to the nature of the investigation, identification scenarios, and results.

The literature reviewed for the project revealed that 26 articles had addressed the nature of the investigation in which CFS was implemented and, later on, had undergone judicial scrutiny. Of these, 8% relate to missing persons' identification (Ross 2004; İşcan et al. 2005), 4% were terrorist attacks (Indriati 2009) and 4% of the articles relate to mass casualty scenarios (Al-Amad et al. 2006). It can be observed that 68% of cases comprised of the identification of one individual (PIOI) (Birngruber et al. 2010; Gordon and Drennan 1948; Simpson 1943; Prinsloo 1953; Sen 1962; Bilge et al. 2003; Pushparani et al. 2012; Ghosh and Sinha 2005; Shahrom et al. 1996; Ubelaker et al. 1992; Bastiaan et al. 1986; Puech et al. 1989;

Table 5.7 Classification of case studies

Author	Nature of investigation					Identification scenario				Result		
	TA	MP	MCI	MG	O	PIOC	PICL	UICL	UIOL	PI	E	U
Glaister and Brash (1937)					x		x				x	
Prinsloo (1953)					x	x				x		
Simpson (1943)					x	x				x		
Gordon and Drennan (1948)					x	x				x		
Webster (1955)					x	x				x		
Sen (1962)					x	x						
Reddy (1973)					x		x			x		
McKenna et al. (1984)					x		x			x		
Teixeira (1985)					x	x				x		
Bastiaan et al. (1986)					x	x				x		
Webster (1955)					x	x				x		
Sen (1962)		x					x			x	x	x
Puech et al. (1989)					x	x				x		
Ubelaker et al. (1992)					x	x				x		
Shahrom et al. (1996)					x	x				x		
Austin (1999)					x	x				x		
Solla and Iscan (2001)					x		x			x		
Bilge et al. (2003)					x	x				x		
Chai et al. (1989)		x				x				x		
Puech et al. (1989)		x							x		x	
Ghosh and Sinha (2005)					x	x				x		
Al-Amad et al. (2006)			x						x	x		
Fenton et al. (2008)					x		x				x	
Shahrom et al. (1996)	x						x			x		
Solla and Iscan (2001)					x	x				x		
Pushparani et al. (2012)					x	x				x		

Teixeira 1985; Webster 1955; Austin 1999; Helmer 1987), 16% addressed CFS identification within a closed list of possible individuals (PICL) (Indriati 2009; Al-Amad et al. 2006; Glaister and Brash 1937; Gordon and Drennan 1948; Simpson 1943; Prinsloo 1953; Sen 1962; Reddy 1973; Solla and Iscan 2001; McKenna et al. 1984; Webster 1955), 8% of the papers reported on the exclusion of a presumed identity within a closed list of possible individuals (UICL) (Glaister and Brash 1937; Gordon and Drennan 1948; Simpson 1943; Prinsloo 1953; Sen 1962; Reddy 1973; Bilge et al. 2003; Pushparani et al. 2012; Ghosh and Sinha 2005; Webster 1955; Fenton et al. 2008), and 8% of papers were related to the identification of individuals whose identity was not presumed, within an open list of possible candidates. Half of the latter cases resulted in identification, and half resulted in exclusion (UIOL) (Al-Amad et al. 2006).

It should be noted that a large number of the cases referred to judicial authorities included identification based on superimposition, corroborated by other identification techniques, that is, comparison of DNA profiles. When no corroboration could be obtained, the superimposition, together with the anthropological profile, was used as the method of identification. The majority of the articles were classified within a general category “others,” which in most cases included single case identification of cadavers in diverse taphonomic conditions, or the identification of historical figures such as Mozart (Puech et al. 1989).

5.3.3 Conclusions

The international survey on the use of CFS as a method of identification among forensic investigators is a unique tool that has provided an important insight into this state of the art of the technique.

The results of the pertinent literature scrutiny and the survey conducted among forensic investigators seem to indicate that CFS is deemed as a reliable and efficient technique of identification, although implemented in conjunction with another method in many cases. From a total of 3854 cases reported worldwide, 32.3% resulted in the positive identification of remains, with 2744 (71.2%) cases submitted to judicial scrutiny.

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