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Standard for Resolving Commingled Remains in Forensic Anthropology

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Foreword

This document is intended to assist forensic anthropology practitioners with the resolution of commingled remains cases. Commingled remains cases are one of the common challenges forensic anthropology practitioners face in medicolegal cases. The resolution of commingled remains aids in individualization and identification of remains.

This document was revised, prepared, and finalized as a standard by the Anthropology Consensus Body of the AAFS Standards Board. The document was initially published by the Scientific Working Group of Forensic Anthropology (SWGANTH) and was further developed by the Anthropology Subcommittee of the Organization of Scientific Area Committees (OSAC) for Forensic Science.

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All hyperlinks and web addresses shown in this document are current as of the publication date of this standard.

Keywords: *forensic anthropology, commingled human remains; Minimum Number of Individuals (MNI); Most Likely Number of Individuals (MLNI); Lincoln Index (LI).*

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1 Scope

This document provides laboratory and field procedures and requirements for resolving commingled remains. The techniques presented include size, age, and sex similarities, articulation between skeletal elements, taphonomic similarities, and reconstruction of fragmentary remains. The document also describes the determination of MNI (Minimum Number of Individuals), as well as the LI (Lincoln Index) and MLNI (Most Likely Number of Individuals) based on the number of paired and unpaired bones.

2 Normative References

There are no normative reference documents. Annex A, Bibliography, contains informative references.

3 Terms and Definitions

For purposes of this document, the following definitions apply.

3.1
articulation
When a skeletal element forms a congruent joint or juncture with another element.

3.2
commingling
The intermixing of biological material representing multiple individuals.

3.3
Lincoln Index
LI
Quantification technique to estimate the actual number of individuals based on the number of paired and unpaired bones.

3.4
Minimum Number of Individuals
MNI
A minimum estimate of the number of individuals represented by a sample; calculated as the number of the most repeated element after sorting by element, side, and developmental status.

3.5
Most Likely Number of Individuals
MLNI
Quantification technique to estimate the actual number of individuals based on the number of paired and unpaired bones; a modified Lincoln Index (LI).

3.6
osteometric comparison
Technique that uses skeletal measurements and statistical models to objectively compare size and shape relationships between elements.

3.7
skeletal
Osseous, cartilaginous, and/or dental tissues.

3.8
visual pair-matching
The association of homologous (i.e., left-right) elements based on similarities in morphology.

4 Requirements

4.1 General

Commingling of human remains is a common component of certain types of incidents, such as mass graves or mass fatalities (e.g., natural disasters or aircraft incidents). Commingling shall be resolved in order to increase the identification potential for the decedents, to return the remains to the next of kin, and for overall investigative success.

During field recovery, practitioners shall thoroughly document the provenience of human remains and associated evidence, to the extent possible, so that this information is maintained and is available for use throughout laboratory analyses.

To the extent possible, remains/evidence shall be collected, transported, and analyzed in a manner to ensure that additional inadvertent commingling does not occur.

4.2 Procedures

Recovery site data shall be documented to record the spatial relationships of remains and material evidence, to the extent possible. Detailed field documentation should include diagrams or maps, unique identifiers of plotted specimens, and photographic and/or video documentation. A field labeling and collection strategy should be used to ensure that remains/evidence are documented and linked to a scene diagram or map and other field documentation. This documentation shall be considered during the laboratory analysis of the remains.

4.3 Sorting

4.3.1 General

When possible, the sorting process should take place in the laboratory. The anthropological sorting techniques used in the resolution of commingling may include provenience data, visual pair-matching, articulation, osteometric comparison, taphonomy, and process of elimination. Related disciplines such as chemistry (e.g., isotopes, XRF) and biology (e.g., DNA) are useful for sorting commingled remains in addition to the anthropological methods detailed below. Most of these sorting procedures are not stand-alone techniques and should be used in conjunction with each other.

With all the procedures described, greater confidence is granted to results that lead to exclusions (i.e., remains showing incompatibility with each other) rather than those that show consistencies.

4.3.2 Inventory and Reconstruction

An inventory of the remains shall be completed with consideration of field provenience and scale of the incident, as appropriate.

Fragmentary remains should be reconstructed to assist in the overall segregation process.

Elements articulated at the time of recovery shall be maintained as an anatomical unit throughout the analytical process, but their association shall be confirmed in the laboratory. Remains that are not articulated by soft tissue or bone shall be considered as potentially originating from different individuals.

4.3.3 Visual Pair-Matching

To facilitate pair-matching, bones shall be sorted by element type, side, and size. Grouping elements by age criteria may also be helpful at this stage of the sorting process. Visual matching of different skeletal elements (e.g., a humerus and a femur) based on morphology should be conducted only in instances that involve a limited number of individuals who exhibit marked skeletal variation.

4.3.4 Articulation

Articulation provides an acceptable means for associating remains. Conversely, poor articulation between elements is a basis for segregating remains. The use of articulation should not be used when remains are extremely fragmented, or when articular surfaces are missing or damaged.

4.3.5 Osteometric Comparison

Osteometric comparison is a technique that uses statistical models to objectively compare size and shape relationships between elements and should be used to segregate remains that cannot be segregated through other means, such as pair-matching and articulation. Software packages can assist with these procedures.

4.3.6 Taphonomic Patterning

Taphonomic patterns can be individualizing, especially due to idiosyncratic circumstances such as when a rust stain from a zipper crosses adjacent bones. However, there may also be drastic taphonomic differences present on the remains of the same individual due to disarticulation, thermal alterations, variable burial context, or preservation. As such, analysis of taphonomic similarities or differences should not be considered a primary sorting technique in most instances. When relevant, taphonomic patterns shall be documented.

4.3.7 Process of Elimination

After other sorting methods are completed, duplicated elements may remain that can be associated with a specific individual through the process of elimination.

4.4 Number of Individuals

4.4.1 General

In some instances, it may be useful to estimate the number of individuals prior to completing the entire sorting process as outlined above. These methods may include the Minimum Number of Individuals (MNI), the Lincoln Index (LI), or the Most Likely Number of Individuals (MLNI), a variation of the LI. The method used depends on the context and scale of the commingling. Consideration should also be given to sex and age differences, as appropriate.

4.4.2 Minimum Number of Individuals (MNI), Lincoln Index (LI), and the Most Likely Number of Individuals (MLNI)

MNI is calculated by sorting the bones by side and element and then taking the greatest number as the estimate. For fragmentary remains, specific segments of an element (e.g., distal femur) can be used for the calculation of the MNI. Every fragment shall share a specific landmark to ensure that fragments do not originate from the same skeletal element. The basic principle of an MNI estimate is to avoid counting the same individual twice.

The Lincoln Index (LI) and the Most Likely Number of Individuals (MLNI) may be used to improve the accuracy of population estimates when compared to the MNI. Both techniques are calculated based on the number of paired and unpaired bones. These techniques are used to estimate the actual number of individuals, as opposed to the minimum number. The LI is calculated in equation (1).

$$LI = (R \times L)/P \quad (1)$$

where

L = total number of lefts,

R = total number of rights,

P = total number of pairs.

While both the LI and the MLNI will provide very similar results in most situations, it is recommended that MLNI should be used since it was derived specifically to remove bias from the estimate. For single elements, the MLNI is calculated in equation (2).

$$MLNI = [(L+1)(R+1)/(P+1)] - 1 \quad (2)$$

where

L = total number of lefts,

R = total number of rights,

P = total number of pairs.

5 Considerations

In such instances where the forensic anthropologist cannot control the recovery site, efforts to collect and retain provenience information should be made. All impediments to this effort shall be acknowledged and documented in daily notes.

As the number of individuals increases, so does the complexity of the forensic investigation and the skills necessary for case resolution. Body fragmentation adds an even further level of difficulty since each separate fragment shall initially be treated as a separate individual until an association can be established.

Chemical and biological (e.g., DNA) analyses add significant power to the resolution of commingling of fragmentary remains. When using DNA profiles as a basis for sorting, the analyst shall be cognizant of the statistical limitations of the DNA sequence data. The forensic anthropologist utilizing DNA profiles shall always consult with the DNA testing laboratory as to the risks of random matches considering the commingling problem.

Segregation of all remains will not always be possible. In these instances, the analyst may assign the unassociated elements to some type of "group" category (jurisdictionally dependent).

Large-scale commingling may introduce logistical problems, such as data management and analytical space, which need to be considered as part of laboratory analysis.

Caution should be applied to pair-matching and articulation when the commingled population is large and homogeneous (e.g., all 17 to 19 year-old males). It is critical that elements can be accurately pair-matched when using the LI and MLNI. When using these methods, errors in pair matching can result in the calculation of misleading estimates.

Osteometric comparisons are amenable to situations in which the remains are fragmentary; however, extensive cortical erosion could produce biased results. The strength of osteometric comparison is to recognize inconsistent relationships which lead to exclusionary sorting (i.e., consistency between elements alone is not sufficient evidence for association). In most instances it is not possible to osteometrically segregate individuals with similar body size and build.

Uncertainty should be considered when applying methods for resolving commingled remains, to include a consideration of method error rates and varying degrees of subjectivity.

6 Reporting

All raw data, techniques, and interpretations shall be documented. Documentation should allow for an independent examiner to assess the approach to resolving commingled remains.

7 Conformance

This standard is not written to support conformity assessment.

Annex A
(informative)

Bibliography

The following bibliography is not intended to be an all-inclusive list, review, or endorsement of literature on this topic. The goal of the bibliography is to provide examples of publications addressed in the standard.

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