Technical Note

Copper Brace Method: A New Technique for Reconstructing Broken Bone Fragments

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Abstract: Human skulls and other bones recovered in forensic anthropological contexts may be found broken into multiple pieces, requiring reconstruction. This article prescribes a new method, termed copper-brace method, that simultaneously enables retaining the matching pieces of bones and readjusting them during the process of reconstruction, ensuring an acceptable likeness in the spatial and contour configuration of the final reconstruction.

Introduction

At times, skulls and other bones requiring forensic analyses are received broken into multiple pieces (Figure 1). Such damage may occur because of forces from explosions, ballistic trauma, vehicular accidents, falls from height, violent assault, or postmortem effects [1, 2]. In practice, fragmented bones are reconstructed to obtain a reasonable likeness for interpreting trauma [3]; facial approximation [2]; identification by comparison with antemortem medical and dental records; or to assess general traits like sex, age, or ancestry. Reconstructing broken pieces of bones, although essential, is a tedious [2, 3]

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Received October 16, 2016; accepted December 14, 2016

Figure 1

Portions of vault with pieces of facial skull.

and challenging process that requires training and experience [2]. Here, the need for precision is well recognized [2–4]. The conventional "sand box method" [3–5] or other procedures [5–7] require affixing physically matching bones using tape or cement. If the bones have been incorrectly affixed, solvents are then used to loosen the glued pieces [4]. When a series of bone fragments are rigidly affixed along their matching edges, minor alterations in the angulations among them accumulate, leading to bad orientation [4]. Loosening the bones makes further reconstruction more laborious because of residual cement along the edges that impedes precise physical matching during repetitive attempts.

The copper brace method prescribed here enables uniting two matching bone pieces by bracing their surfaces while leaving the physically matching edges to move freely so that minor adjustment is still possible for acquiring acceptable configuration when adding further bone pieces. Thus, maneuverability among multiple matching bone pieces enables correcting alterations in their angulations to achieve a reasonable reconstruction.

Method and Discussion

Physical matching between edges of two bone fragments was ascertained by recognizing their anatomical structures and then conjoining the broken edges. Physical matching was confirmed by careful visual appraisal of the points of conformance on the outer and inner surfaces of the bones and by tactile maneuvering of the bones in the matched state. Locations for bracing the two matching pieces of bones were chosen along the sides of the conjoining break surfaces. (Depending on the length of the line of match, such locations can be spaced out about 2 to 3 cm from each other.) The dirt and greasy deposits on the bone surfaces in the selected locations were cleaned using suitable agents, taking care not to damage the bone surface. A piece of copper sheet [LR grade, 38 gauge (0.1 mm)] was cut into strips of about 3 to 4 mm in breadth and of varying lengths. One side of the copper strip was abraded using a fine emery sheet to obtain a matt finish. A suitable length of the copper strip was cut and shaped by maneuvering using fingers to fit the surface characteristics of the matching bones. Droplets of cyanoacrylate adhesive were placed on the surfaces of the matching bones well away from the conjoining break surfaces, and the cut copper strip was placed on the droplets, spanning the break and bracing the fragments (Figures 2, 3). Another method is to hold the bone pieces in their physically matched state and place the abraded surface of the copper strip in contact with the bone surface across the fracture line. Droplets of cyanoacrylate adhesive can be applied in the area of contact between the bone surface and copper strip so that the glue gently seeps in between, binding them together. Excess adhesive, if any, can be removed using the edges of a blotting paper. Here, it is important to restrict the adhesive from running into the physically matching fracture surfaces. Additional pieces of bones that demonstrate physical matching are added along the free edges of the braced bone fragments to obtain a zone. Because the copper strips brace the surfaces of matching bones, the bone edges remain free and maneuverable (Figure 4).

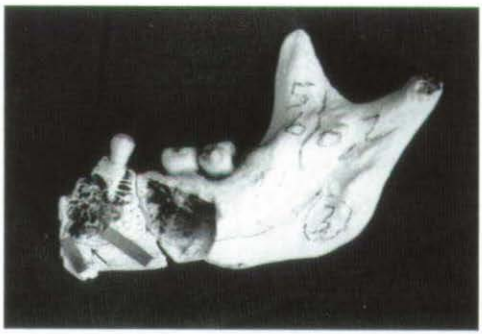


Figure 2

Copper braces placed on droplets of cyanoacrylate adhesive.

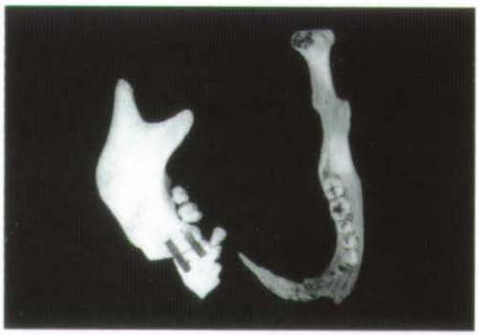
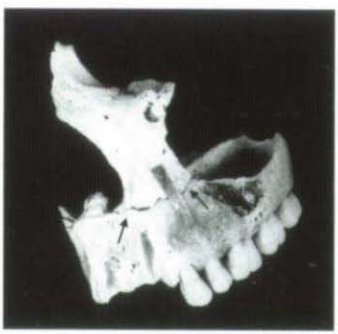


Figure 3

Components of the mandibular zone nearing completion.



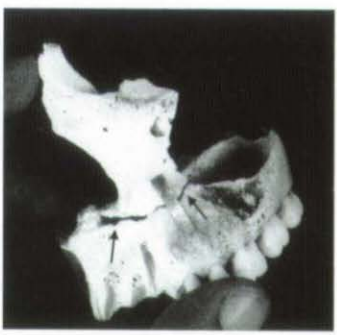


Figure 4

Illustration of the maneuverability (arrows) along the two matching edges that are retained using a copper brace.

Reconstruction is better achieved when the bones pertaining to different zones are reconstructed as separate units [4] and are then joined to form the complete bone, such as the skull. Such zones may include the mandible zone (Figure 3), naso-maxillary zone (Figure 5) and the orbito-zygomatic zone. Normal occlusion between the upper and lower rows of teeth would illustrate natural orientation of the mandible and naso-maxillary zones (Figure 6). The mandible and naso-maxillary complex were united with the orbito-zygomatic zone by adjusting the physically matching fractured edges that corresponded as well as by appropriately fitting the condyles of the mandible in the temporo-mandibular fossae (Figure 7). The edges of the bones of the vault were then braced with the corresponding physically matching edges of the bones of the facial complex (Figure 8). (During the process of combining the various zones, minor differences in the orientation of the matching bone edges are usually found and are duly adjusted by manipulating the neighboring physically matching edges in the complex that are still free to maneuver. Scientific acceptability of reasonable likeness is justified when the bone edges pertaining to one zone physically match with their counterparts in the adjoining zone.) Once a satisfactory contour of the skull was obtained, the interspaces between the physically matching bones were further stabilized by seeping cyanoacrylate adhesive into those spaces. (If desired, the copper strips can be removed by dissolving the adhesive with acetone.)

Figure 5

Reconstructed naso-maxillary zone. Neighboring bones can be retained using copper strips leaving missing areas (arrow) as such.

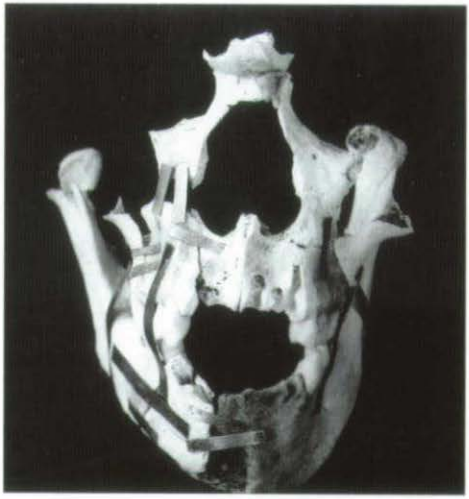


Figure 6

Combination of the mandibular and maxillary zones ensuring normal occlusion.

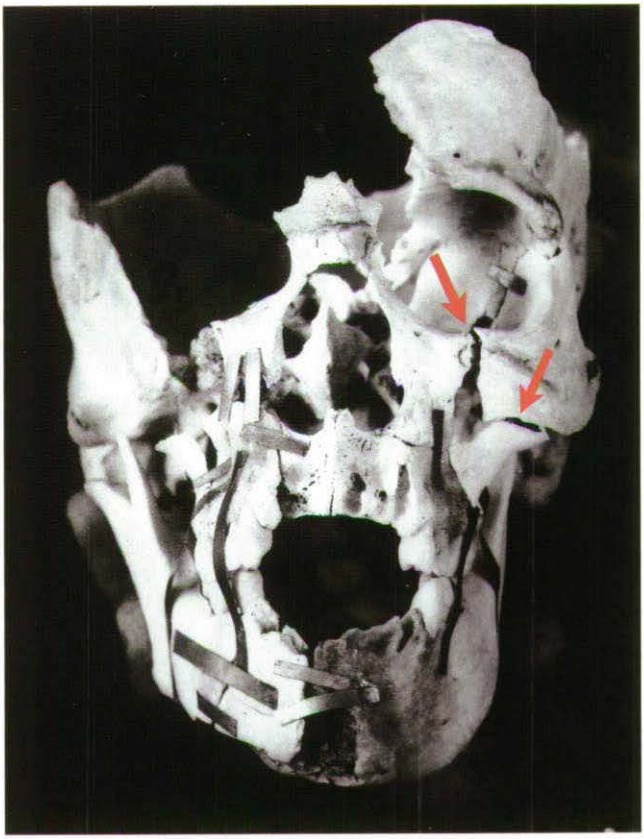


Figure 7

Combination of the mandible and naso-maxillary complex with the orbito-zygomatic zone indicating incomplete physical matching between the corresponding fractured bone edges (arrows), which can be adjusted to match because the neighboring matching edges are maneuverable.

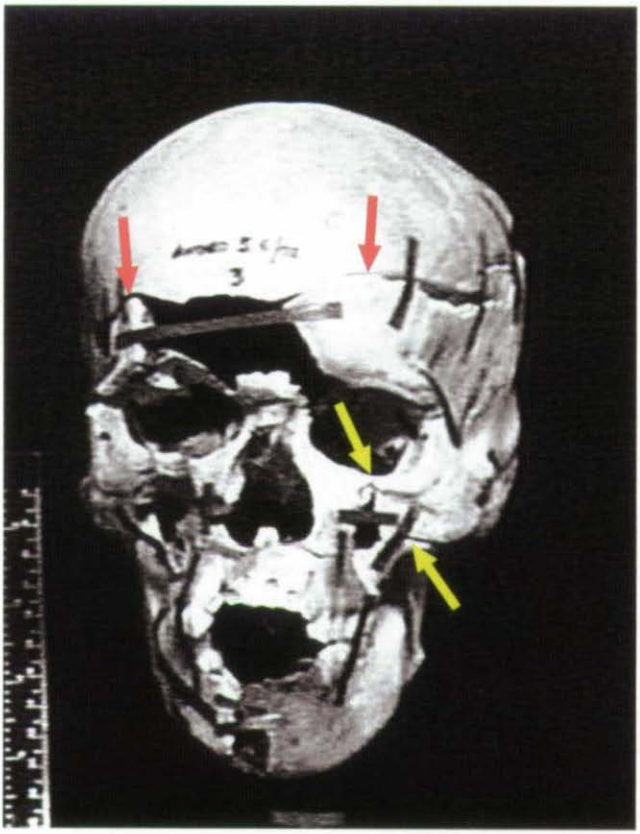


Figure 8

Video image of the reconstructed skull positioned for superimposition. Yellow arrows indicate the physically matching edges shown in Figure 7 after readjusting. Physical matching between the facial and vault components (red arrows) supports the validity in the reconstruction.

Conclusion

The benefit in using the copper brace method described here is that the copper strips, acting as braces, instantly hold onto the surfaces of matching bone pieces, maintaining their matched state while still permitting a degree of movement between the conjoining edges of the bones, permitting a reconstruction that would enable bone trauma analysis or assessment of ancestry, sex, and individual identity. Here, the major advantage is the ability to readjust and correct minor differences in the angulations while adding multiple bones, thus obviating the chances of accumulation of such deviations that may result in incorrect orientation. Thus, the laborious task of loosening the badly affixed bones using solvents and redoing the procedure after identifying bad orientation is avoided.

Acknowledgment

The authors are thankful to Dr. C. Damodaran, Director (Rtd.), Forensic Sciences Department, Chennai, India, for his encouragement. The authors acknowledge the assistance of Ms. C. Bhavani and Mr. K.B. Thaiyub Mohamed, Forensic Sciences Department, Chennai, India, during the analysis of the case described in this report.

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