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IDENTIFICATION AND MEASUREMENTS OF ARTIFICIAL CRANIAL MODIFICATION IN DIAGUITA III PEOPLES OF CHILE'S SEMIARID NORTH

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Abstract

This work reports on the identification and measurements of artificial cranial modification (ACM) of the osteological collection from the sites Peñuelas, Peñuelas 21 and 24, Illapel, Pisco Control, and El Olivar excavated from Chile's, semiarid north (corresponds largely with Region de Coquimbo). The Museo Arqueologico de La Serena (MALS) holds these osteological collections that represent the Diaguita culture (Phase III, agriculturalists, 1450-1536 C.E.) and excavated by Ampuero (1989) and Biskúpovic (1982-85, 1999). The pooled sample is composed of 48 individuals, mostly adults, and their rather intact preservation has permitted on-going bioanthropological documentation, including that of artificial cranial modification (ACM) and paleopathologies. In this analysis, ACM of the tabular erect type was identified, and measurements were taken on standard skull landmarks to document skulls with ACM and no ACM. The analysis indicates that both males and females present ACM of the tabular erect type. There does not seem to be preferential modification linked to one of the sexes. The measurements for ACM skulls also revealed that there are statistically significant differences between males and females in the pattern of increase and decrease of the average, or median, measurements of specific skull landmarks. Two sets of T-tests or Wilcoxon Rank-Sum were accomplished on all measurements. Comparisons were made between male non-ACM and female non-ACM skulls for each of the twelve landmark measurements. Another set of comparisons was accomplished between male ACM skulls and female ACM skulls for each of the twelve landmark measurements. For all T-tests and Wilcoxon Rank-Sum tests it was decided to use a two-tailed T-test with alpha values of 0.02 for an alpha of 0.01 both ways for the T-tests. The results support a differential treatment process between the sexes in ACM in Diaguita III peoples such that the variation in the pattern itself between the sexes was intentional in the process of modifying the skulls of infants.

Keywords

Bioarchaeology, Artificial Cranial Modification (ACM), Tabular Erect, Taphonomy

Introduction

Artificial Cranial Modification as a practice begins during infancy shortly after birth and does not extend beyond three years of age (Tomasto-Cagigao, 2017). It is produced by the application of external forces, tension, in the cranial vault using rigid or flexible modification devices that modify the shape of the skull (Dembo and Imbelloni 1938, Buikstra and Ubelaker 1994). In this way, the product of the applied tension, the modification, affects not only the cranial vault but also the facial bones that are largely explained by changes in the dimensions of the peripheral structures (Anton 1989). In the North of Chile, cases of ACM have been recorded since the Archaic period, in the hunter-gatherer groups of the Chinchorro Culture, continuing in the periods Early, Late Intermediate, and Late until it was discontinued during the Colonial period by the prohibition of idolatries of which ACM was considered a part of (Manríquez et al., 2006).

Dembo and Imbelloni (1938) established two types of ACM and two variants for each: tabular and circular-oblique; tabular erect, tabular oblique; circular erect, circular oblique.

Their results were obtained from the analysis of osteological collections from Northern Chile, San Pedro de Atacama, Coyo Oriente collection that indicate the predominance of tabular erect modification compared to annular and tabular oblique modification. According to the authors, tabular erect modification would have been the type of intentional cranial modification characteristic of the Salar de Atacama during the middle period.

Torres-Rouff (2007) identified ACM in sites of the Early Intermediate Period (Toconao Oriente) Middle Horizon (Solcor 3) Late Intermediate (Catarpe 2-3-4 and 5, Quitor 6, Yaye 1-2-3 and 4, Coyo 3) and the Late Horizon (Catarpe1) belonging to the collection of the Gustavo Le Paige Museum in San Pedro de Atacama, Chile. The study revealed, as in the previous case, that most of the modified skulls present the tabular erect type. However, the author also detected the presence of the circular and erect circular modification, and oblique, although these are not numerous. The studies carried out in Arica (Manríquez et al. 2006), unlike those registered in San Pedro de Atacama, indicate that the majority of deformed skulls are of the circular type in their two erect and oblique variants and suggest the occurrence of a morphological continuity between the Prehispanic populations of the coast and the valleys.

The Museo Arqueológico de La Serena, Chile holds osteological collections in exceptional preservation that cover a period of at least 3,000 years. These collections include those that represent the Diaguita culture that inhabited Chile's coast and interior valleys of the semiarid north over a thousand years ago. Their archaeological remains have been excavated in the 1980s and 1990s from the sites of Peñuelas (sectors 21 and 24; a littoral site that has yielded human and animal skeletal remains); and from Illapel and Pisco Control, interior valley sites (see Fig. 1). The sites have been dated via C14 to approximately 600 years ago and are located in Chile's Region de Coquimbo which corresponds very closely with the semiarid north (Ampuero 1989; Biskupovic, 1982-85, 1999). The Diaguita Culture has been widely studied by Cornelli (1956), Julio Montané (1969), Gonzalo Ampuero (1975), Biskupovic (1982-85, 1999) and more recently by Paola González (2013). The Diaguita cultural development takes place between 1,200 and 1536 C.E., thus establishing a chronological sequence of three phases based on the evolution of pottery forms and styles: Phase I (Diaguita I, 1000-1200 C.E.), Phase II (Diaguita II, 1200-1450 C.E.) and Phase III (Diaguita-Inca 1450-1536 C.E.) covering the valleys of Copiapó, Huasco , Elqui, Limarí and Choapa of Chile's semiarid north.

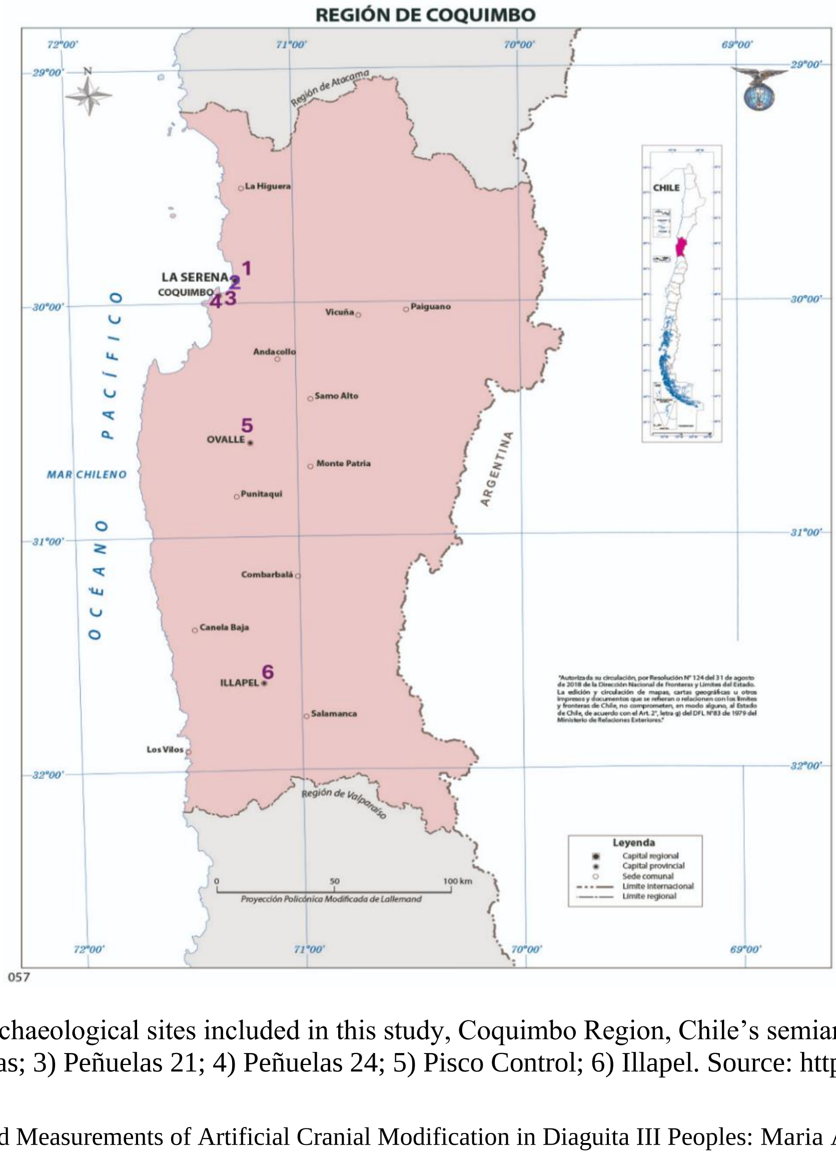

Fig. 1: Map of archaeological sites included in this study, Coquimbo Region, Chile's semiarid north: (1) El Olivar; (2) Peñuelas; 3) Peñuelas 21; 4) Peñuelas 24; 5) Pisco Control; 6) Illapel. Source: https://www.igm.cl/

The skeletal collections studied in this analysis represent the Diaguita culture, Phase III (based on pottery analyses; Biskupovic 1982-85, 1999; Ampuero 1989), represented by farming, pastoralist, and maritime peoples. The mostly intact preservation has permitted studies on paleopathology (Rosado; 1994, 1998; Rosado and Urizar, 2014; Rosado and Vernacchio, 2006), including the identification of ACM in Peñuelas 21 and Peñuelas 24 skulls (Rosado and Vernacchio, 2006). This preservation can be attributed to a semiarid climate that for thousands of years has been largely temperate (mean annual temperature is 15^0 C), with annual rainfall ranging between approx. 80 and 300 mm per year from the littoral to the Andes (Favier *et al.* 2009)**.** Thus, the skeletal remains were interred in soils that have experienced in the distant and near past largely low levels of moisture and reduced extreme temperatures resulting in minimal impact on bone integrity. In addition, the soil pH is neutral. These taphonomic conditions have been favorable in the preservation of human and animal bones (Rosado; 1994, 1998). The Peñuelas, Illapel, El Olivar, and Pisco Control skeletal collections preserve many individuals with almost intact skulls, permitting specific measurements of cranial landmarks for the purposes of documenting the identified tabular erect type of ACM of adult males and females, and to document how the type of ACM impacted cranial dimensions.

ACM in Diaguita III peoples

Artificial cranial modification has been studied for various pre- Columbian populations of Chile and documented via measurements and radiographs by Cocilobo et al. (1995), Manriquez et al. (2006), and Munizaga (1987). Also, Ericksen (1960) documented ACM in Diaguita III peoples. These studies provide the identification of tabular erect ACM with brief descriptions and only a few measurements of the skulls. Biskupovic (1999), and Cantarutti and Mera (2004) also report on intentional cranial modification for Diaguita III populations as that of tabular erect, but their studies do not document the skulls via measurements and do not undertake a comparative analysis of the pattern of increase or decrease in the skull landmark measurements. Rosado and Vernacchio (2006) only identified the practice of ACM in the Peñuelas skulls as that of the tabular erect type but also did not document the practice through measurements.

Research design

Objective and hypothesis

The objective of this analysis was to: (a) document, via measurements of the specific skull landmarks, skulls with ACM of the tabular erect type and no ACM in this pooled sample comprised of the various sites corresponding to Diaguita III phase (Peñuelas, Peñuelas 21 and 24, Illapel, Pisco Control, and El Olivar); and (b) to determine if there are differences in the averages or medians of each of the measurements with observed tabular erect ACM between males and females. The objective was accomplished by:

1. measuring standard skull landmarks, as provided by Bass (2005) of ACM and no ACM skulls;
2. comparing average or median skull landmark measurements between individuals with ACM and without ACM, and between males and females; and
3. selecting samples from the existing population of measured skulls using a code created in python. This assigned each skull with a binary number, 1 or 0, all 1s were used while 0s were not used. This was the mathematical method in which randomness was integrated. Then, the data was charted, and Shapiro-Wilks tests were completed to assess the normality. These used a threshold of .2 as a p-value. If the Shapiro-Wilks test failed and the sample size was below 15, a Wilcoxon Rank-Sum test was completed in place of a regular T-test. All T-tests and Wilcoxon Rank-Sum tests used a p-value of .02 and the normal curves were two-tailed. A p-value of .02 was chosen due to the smaller sample sizes. Different null and alternative hypotheses were used for each measurement in both cases of ACM and non-ACM.

For the T-tests for ACM skulls that were used for each measurement:
Null hypothesis: there exists no statistical difference between the mean male and female ACM skull measurement.
Alternative hypothesis: there exists a statistical difference between the mean male and female ACM skull measurement.

For the Wilcoxon Rank-Sum tests for ACM skulls that were used for each measurement:
Null hypothesis: there exists no statistical difference between the median male and female ACM skull measurement.
Alternative hypothesis: there exists a statistical difference between the median male and female ACM skull measurement.

For the T-tests for non-ACM skulls that were used for each measurement:
Null hypothesis: there exists no statistical difference between the mean male and female non-ACM skull measurement.

Alternative hypothesis: there exists a statistical difference between the mean male and female non-ACM skull measurement.

For the Wilcoxon Rank-Sum tests for non-ACM skulls that were used for each measurement:

Null hypothesis: there exists no statistical difference between the median male and female non-ACM skull measurement.

Alternative hypothesis: there exists a statistical difference between the median male and female non-ACM skull measurement.

Materials and Methods

The total number of skulls for the pooled sites (Peñuelas, Peñuelas 21 and 24, Illapel, El Olivar, and Pisco Control) is 48. ACM was observed in 30 adults in age ranges starting with 18 years and older and in three subadults (determined to be 17 years and younger). Of the 48 skulls, 33 exhibit ACM, or 68% (males, 19 skulls= 69%; females, 14 skulls= 66%). There were six male (23%) and six female (28.5%) skulls without ACM. There were also four skulls for which it was not possible to determine if ACM was present.

Table 1 indicates the number of individuals with ACM by age and sex.

SITES **Peñuelas 21**	**Male**	**Female**	**ACM**	**No ACM**	**NP.**
0-9 y				1(I)	
10-17		1	1		
18-29	2	1	3		
40-49	1		1		
Peñuelas 24					
18-29	2	1	1	2	
30-39	2	2	2	2	
40-49	1	2	1	2	
50+	1			1	
Peñuelas					
18-29	3	2	4	1	
30-39	5	1	5	1	
50+		1	1		
Pisco Control					
10-17	1				1
18-29	3		2		1
30-39		3	3		
40-49	1	2	2		1
50+		1	1		
El Olivar					
30-39	1		1		
50+		1	1		
Illapel					
30-39	1		1		
40-49	3	1	2	1	1
50+		1	1		
TOTAL; n=48 (M, F)	**27**	**21**	**33**	**11**	**4**

Table 1: Available subadults and adults with ACM and no ACM by sex and corresponding age ranges. Key: n=sample size; M=male, F= female, I= undetermined sex; ACM= artificial cranial modification, NP= not possible to determine if ACM present.

The methods of analysis included the identification of sex and age. Measurements were taken of bone elements as necessary to support identifying features of age and sex (Bass, 2005). Characteristics used to determine subadult and adult age included epiphyseal fusion of long bones, changes to the pubic symphysis, and changes to the auricular surface. Anatomical characteristics of the pelvis and skull were used to assign sex. The selected landmarks for cranial measurements used standard, manual, spreading and sliding calipers (Bass, 2005).

a. Estimation of the minimum number of individuals (MNI) to determine sample size: bone elements were grouped into diagnostic anatomical units considering age, taphonomic characteristics, and articulation (Ubelaker, 1978).

b. Estimation of sex was based on standard morphological criteria of skull and pelvis (Buiktra and Ubelaker 1994), in some cases metric methods, considering the diameter of the femoral head and the humerus were used (Bass 2005). Individuals were categorized as Female (F), Male (M), and Undetermined (I). The estimation of sex in one subadult individual (included in age range 0-9 years) was not determined because the skeleton may not present defined sexual characteristics at bone morphology level, thus would result in an unreliable estimation.

c. Estimation of the age of death was carried out using macroscopic methods related to the morphological changes in the pubic symphysis (Suchey and Brooks 1990), the auricular surface (Buckberry and Chamberlain 2002), and epiphyseal fusion (Scheuer and Black 2007).

d. Skull landmarks for measurements selected from Bass (2005) are among standard measurements included in a variety of studies on craniometry and ACM (Anton, 1989; Rhode and Arriaza, 2006; Ross and Ubelaker, 2009; Pomeroy et al., 2010).

Table 2 indicates measurements of selected landmarks that were taken on the skulls:

Landmark numbers	**Cranial and mandibular Landmarks**	**Description**
(1)	Basion-Prosthion Ht.	Basion-Prosthion Height
(2)	Glabello-Occipital	Glabella-Occipital
(3)	Maximum Width (Eu-Eu)	Eurion-Eurion
(4)	Basion-Bregma Ht.	Basion-Bregma Height
(5)	Basion-Nasion Ht.	Basion-Nasion Height
(6)	Maximum Diameter (Bizygomatic)	Bizygomatic
(7)	Prosthion-Nasion Ht.	Prosthion-Nasal Height
(8)	Nasal Height	Nasal Height
(9)	Bigonial Breadth	Bigonial Breadth
(10)	Ht. Ramus	Height of Ramus
(11)	Occip. Ang	Occipital angle
(12)	Frontal	The Distance between the two frontotemporal

Table 2: Cranial and mandibular landmarks for measurements used in this study (Bass, 2005).

Results

The artificial cranial modification that has been identified is that of tabular erect, or bifronto-occipital (see fig. 1). This type of modification has been described by Munizaga (1987) and Neumann (1942) for Andean and Native North American populations, respectively. Bifronto-occipital cranial modification results from the posterior and anterior compression of the frontal and occipital bones and affects the sagittal suture by dividing the posterior aspect of the calvarium into two rather distinct lobes. Bifronto-occipital modification consists of bilateral flattening that produces a narrow frontal bone associated with a moderate degree of vertical occipital flattening and plagiocephaly. This type of artificial modification resulted from applying pressure to the forehead and occipital bones of infants. This could have been the result of a tight strap with a board placed posteriorly where the occipital is guided to achieve the vertical flattening. There does not seem to be preferential modification linked to one of the sexes.

The following sets of photos, lateral views, are examples of adult male and female skulls with and without ACM: Fig. 2, ACM, male; Fig. 3, no ACM, male; Fig. 4, ACM, female; Fig. 5, no ACM, female; (Fig. 4 indicates scale: 5cm, skull photos are proportional to each other).

(a):

Fig. 2: Lateral view with ACM
(Peñuelas, esq. 954, M, 35+ years)
Key: esq.= skel. and number, M=male, += plus

Fig. 3: Lateral view, no ACM
(Peñuelas, esq. 953, M, 40+ years)
Key: esq.= skel. and number, M=male+= plus

(b):

Fig. 4: lateral view ACM
(Peñuelas, esq. 73-29-1, F, 16-17 years)
Key: esq.= skel. and number, F= female

Fig. 5: lateral view no ACM
(Peñuelas, esq. 1052, F, 35+ years)
Key: esq.= skeleton and number, F=female, += plus

Table 3 indicates differences in the averages of skull landmark dimensions for males and females with no ACM and with ACM.

LANDMARK NUMBER	AVERAGES FOR MEASUREMENTS	NO ACM MALES	ACM MALES	NO ACM FEMALES	ACM FEMALES
(1)	Basion-Prosthion Ht.	**102**	**101.0294118**	**94.2**	**87.625**
(2)	Glabello-Occipital	**151.8**	**145.1176471**	**154.1**	**136.75**
(3)	Maximum Width (Eu-EU)	139.2142857	148.425	136	147.5384615
(4)	Basion-Bregma Ht.	132.6666667	133.3333333	**138.2**	**131**
(5)	Basion-Nasion Ht.	**103**	**99.70588235**	**95.2**	**92.57142857**
(6)	Maximum Diameter (Bizygomatic)	131	135.2857143	**130.6666667**	**126**
(7)	Prosthion-Nasion Ht.	61.66666667	63.88888889	61.33333333	61
(8)	Nasal Height	21.66666667	23.375	**28.83333333**	**22.11111111**
(9)	Bigonial Breadth	82.125	97	**92.25**	**89.375**
(10)	Ht. Ramus	**76.33333333**	**63.32142857**	55.75	56.72727273
(11)	Occip. Ang	21.2	23.78947368	**25**	**17.54545455**
(12)	Frontal	91.75	96.25	84.5	95.5

Table 3: Average skull landmark measurements (mm) for males and females, no ACM and ACM.

The measurement landmarks in deformed female skulls show a decrease in size for eight average dimensions (see measurements 1, 2, 4, 5, 6, 8, 9, 11 in bold in Table 3) as opposed to only four for males (see measurements 1, 2, 5, and 10 in bold in Table 3). Table 4 indicates T-scores, Wilcoxon Rank-Sum scores, p-values, and compares averages for skull measurements of ACM skulls for both males and females where half of the P-values used a threshold of .02 as a two-tailed test. The measurements that failed the Shapiro-Wilks Tests for ACM skulls were: Basion-Prosthion Ht. (for males), Glabello-Occipital (for males and females), Maximum Width (Eu-Eu) (for females), Basion-Bregma Ht. (for males and females), Basion-Nasion Ht. (for males), Prosthion-Nasion Ht. (for males), Nasal Height (for females), Occip. Ang (for males and females), and Frontal (for females). The tests in Table 4 indicates (in bold) that four of these measurements are statistically different between males and females for ACM skulls (measurements 1, 5, 6 and, 10 in Table 4), and this includes average measurements 1, 5, and 10 which decrease in males with ACM. However, the skulls with no ACM did not have any statistically different average or median landmark measurements (Table 5).

	AVERAGES FOR MEASUREMENTS	ACM MALE	ACM FEMALE	T-SCORE	WILCOXON RANK-SUM	P-VALUE
(1)	**Basion-Prosthion Ht.**	**101.0294118**	**87.625**	**2.718628421**	----------------	**.0064**
(2)	Glabello-Occipital	145.1176471	136.75	----------------	1.30745	.0956
(3)	Maximum Width (Eu-Eu)	148.425	147.5384615	----------------	.46206	.3220
(4)	Basion-Bregma Ht.	133.3333333	131	----------------	.92809	.1767
(5)	**Basion-Nasion Ht.**	**99.70588235**	**92.57142857**	**3.20068411**	----------------	**.0022**
(6)	**Maximum Diameter (Bizygomatic)**	**135.2857143**	**126**	**2.529470613**	----------------	**.0099**
(7)	Prosthion-Nasion Ht.	63.88888889	61	1.498505272	----------------	.0739
(8)	Nasal Height	23.375	22.11111111	----------------	1.00023	.1586
(9)	Bigonial Breadth	97	89.375	2.048749565	--------------	.0282
(10)	**Ht. Ramus**	**63.32142857**	**56.72727273**	**2.54073961**	--------------	**.0095**
(11)	Occip. Ang	23.78947368	17.54545455	----------------	1.92392	.0272
(12)	Frontal	96.25	95.5	----------------	0	.5000

Table 4: Means and T-scores comparing ACM skulls in males and females (mm).

Table 5 indicates T-scores and Wilcoxon Rank-Sum tests and compares averages or medians of the measurements of non-ACM skulls for both males and females. In 7 of the cases, the Wilcoxon Rank-Sum test was completed due to certain measurements failing the Shapiro-Wilk test. The measurements that failed the Shapiro-Wilk tests were: Basion-Prosthion Ht. (for males), Glabello-Occipital (for males), Basion-Bregma Ht. (for males), Basion-Nasion Ht. (for males and females), Maximum Diameter (Bizygomatic) (for females), Prosthion-Nasion Ht. (for males), and Nasal Height (for females). All P-values are above the level of acceptance. (p-value > 0.02). Males and females in this pooled sample indicate that skull measurements are non-statistically different for all measurements, with no differences in the pattern of increase or decrease.

	AVERAGES FOR MEASUREMENTS	NO ACM MALE	NO ACM FEMALE	T-SCORE	WILCOXON RANK-SUM	P-VALUE
(1)	Basion-Prosthion Ht.	102	94.2	-----------------	-.82724	.2040
(2)	Glabello-Occipital	151.8	154.1	-----------------	-.31429	.3767
(3)	Maximum Width (Eu-Eu)	139.2142857	136	0.6791675946	-----------------	.2636
(4)	Basion-Bregma Ht.	132.6666667	138.2	-----------------	.36598	.3572
(5)	Basion-Nasion Ht.	103	95.2	-----------------	-.64047	.2610
(6)	Maximum Diameter (Bizygomatic)	131	130.6666667	-----------------	.25928	.3977
(7)	Prosthion-Nasion Ht.	61.66666667	61.33333333	-----------------	-.32195	.3738
(8)	Nasal Height	21.66666667	28.83333333	-----------------	.48464	.3140
(9)	Bigonial Breadth	82.125	92.25	-1.177048765	-----------------	.1579
(10)	Ht. Ramus	76.33333333	55.75	1.580963923	-----------------	.1254
(11)	Occip. Ang	21.2	25	-0.773419226	-----------------	.2336
(12)	Frontal	91.75	84.5	1.595591808	-----------------	.1748

Table 5: Means and T-scores comparing non-ACM male and female skulls.

Discussion

The analysis, not accomplished in any study to date for the skulls in this sample, set out to measure specific skull landmarks with the objective of documenting the identified ACM of the tabular erect type in the pooled sample of Diaguita III phase sites. to determine if there are differences in the pattern of increase or decrease in average or median skull landmark measurements between males and females. First, it was found that there does not seem to be preferential modification linked to one of the sexes. Second, it was expected that both males and females would have the same pattern of increase or decrease in average or median measurements for the skull landmarks measured, but that is not what is indicated by the measurements. In this pooled sample, the average measurements indicated that ACM males and ACM females did not have the same pattern of increase or decrease in measurements. It was then tested mathematically if the differences were significant in average or median landmark measurements between ACM (males vs. females) and no ACM (males vs. females) skulls. It was expected both

male and females with ACM to not be statistically different in average or median measurements, but that is not what is revealed by the measurements and mathematically by the T-tests or Wilcoxon Rank-Sum tests. Four of the average measurements (all tests which resulted in a p-value with less than .01 were T-tests) are statistically different between males and females for ACM skulls (measurements 1, 5, 6, and 10), including three of those that indicate differences in the pattern of decrease for males with ACM (measurements 1, 5, and 10). However, the skulls with no ACM did not have any statistically different average measurements or differences in the pattern of increase and decrease.

It is possible that the statistically different average measurements between the sexes are the result of differential pressures and techniques applied in the modifications to the skull landmarks and\or with different lengths of time between male and female infants. The differences in the pattern of the average landmark measurements in ACM skulls cannot be explained solely as the result of sexual dimorphism in craniofacial growth pattern. The craniofacial growth study of Ursi et al. (1993) supports this assertion. Ursi et al. investigated sexual dimorphism in non-artificially modified craniofacial growth of adult skulls (samples were all Caucasian). They demonstrated that of the facial and cranial dimensions, length of the anterior cranial base was indeed larger in males, but the base angle of the cranium was similar for both males and females. In addition, the direction of facial growth was similar for both males and females, with females demonstrating a somewhat more horizontal growth pattern. Thus, craniofacial growth differences between the sexes exist, but are minimal. Based on the average landmark measurements and tests we propose the following tentative explanation for the Diaguita III skulls with ACM and differences between the sexes in average landmark measurements: the differences are likely the result of differential treatment and intentionality on the part of those accomplishing the ACM in infants. There is intentionality in the manipulation of the pressures and\or different lengths of time of pressure applied to the crania of infants that have resulted in differences between males and females in the pattern of increase and decrease of the average landmark of four of the measurements. This is not only supported by the T-tests on average landmark measurements, but also further supported by the tests completed on male and female skulls with no ACM, indicating that the statistical differences between the sexes landmark measurements are not significant, and likely also reflective of less sexual dimorphism in craniofacial growth pattern.

Conclusion

The Diaguita III peoples of Chile's semiarid north (Region de Coquimbo) practiced ACM of the tabular erect type. The measurement of skull landmarks for ACM skulls revealed a different pattern of increase and decrease in the average or median measurements between male and female Diaguita III skulls with ACM. This was statistically tested through T-tests and Wilcoxon Rank-Sum tests and was discovered that statistically significant differences in the pattern of increase and decrease of the average landmark measurements for ACM male and female skulls exist, for four measurements, while male and female skulls with no ACM do not indicate statistically significant differences in the average measurements. We propose that the differences in the pattern of increase and decrease of the average measurements have an implication: it is probable that there was differential treatment between the sexes in ACM in Diaguita III peoples such that the variation in the pattern itself between the sexes was intentional in the process of modifying the skulls of male and female infants.

To further support that Diaguita III people practiced differential treatment between the sexes and intentionality in ACM, future studies on ACM in Diaguita III peoples should: (1) include a larger skeletal sample (from recently excavated sites in Chile's semiarid north); (2) measurements of the skull not included in this study; and (3) application of additional correlational tests. It is expected that there will be similar results in the pattern of increase and decrease in the average or median landmark measurements.

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