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An experimental approach to the study of interpersonal violence in Northeastern Patagonia (Argentina), during the late Holocene

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ABSTRACT

This paper incorporates an experimental approach to the study of violence patterns in Northeastern Patagonia (Argentina) during the late Holocene. The underlying hypothesis considers a close association between socio-ecologic alterations during the Medieval Climatic Anomaly (MCA) (*ca.* 1150–600 years BP; Stine, 1994, 2000) and a probable increase in conflict levels. In order to test this hypothesis, human skulls ($n = 986$) were analyzed for bone lesions, discriminating late bone lesions, such as those produced by metal tools. The experimental approach used swine (*Sus scrofa domestica*) skulls, as proxies for human skulls, and incorporated original sabers. From this discriminating analysis, it can be inferred that no significant increase in violence signs were recorded until the first stages of Hispanic-indigenous contact (first half of 17th century). These findings emphasize the need for a revision of the implications of the dynamics of human populations in Northeastern Patagonia during the late Holocene.

1. Introduction

It is traditionally believed that ancient population groups were inherently peaceful (Keeley, 1996). However, in the last decades, a thorough compilation and systematization of available information, consisting mainly of direct (*i.e.* human remains) and indirect (*e.g.* defensive sites and associated technologies, rock art evidence), has made it possible to corroborate the existence of elevated rates of violence in certain small-scale prehistoric societies (Lambert, 1997, 2002; Milner, 1995; Walker, 1989, 2001).

For Southern South America, even though individual cases with evidences of violence have been recorded in hunter-gatherer groups (Barrientos, 1997; Barrientos and Gordón, 2004; Berón et al., 2007; Constantinescu, 2003; Flensborg, 2011; García Guraieb et al., 2007; Gómez Otero and Dahinten, 1997–98; Gordón, 2009a, 2009b, 2009c; Gordón and Ghidini, 2006; L'Heureux and Amorosi, 2009; Scabuzzo, 2010; Vignati, 1947), and putative defensive sites have been identified (Goñi, 1983–85, 1986–87), there are no general contexts within which these cases could be interpreted. In other words, no reference frameworks have been created in order to systematize and interpret those evidences of violence in small-scale societies at a population scale (Gordón, 2011).

A possible increase in violence levels has been suggested for Northeastern Patagonia, Argentina (Fig. 1), in relation to the ecological modifications related to the Medieval Climatic Anomaly (MCA) (1150–600 years cal. BP; Stine, 1994, 2000), in the context of a population dynamic model for the Southeastern Pampean, and Northeastern Patagonian regions (Barrientos and Pérez, 2004; Barrientos and Gordón, 2004).

This model links environmental features (*e.g.* epic draughts, major habitat fragmentation) to socio-ecological processes such as: a) reduced residential mobility; b) increased scarcity of usable space; c) population nucleation/aggregation in areas with higher resource concentration and availability (*e.g.* lower basins of large rivers and Atlantic shoreline); d) local or meso-regional increase in population density; e) changes in socio-political and economic organization (*e.g.* the arise of linear-descent corporative groups, incorporation of a processor-type economic strategy, (in the sense of Bettinger and Baumhoff, 1982); and f) increase in within- and between-group competition. These have been pointed out as possible causes leading to fission and geographic expansion of these populations, after 1000 years BP.

This paper is inserted within the context of previous research that evidenced the prevalence of a certain kind of bone lesion in an archaeological sample of human skulls. The analysis of a sample of human skulls ($n = 797$) from Northeastern Patagonia (*Museo de La*

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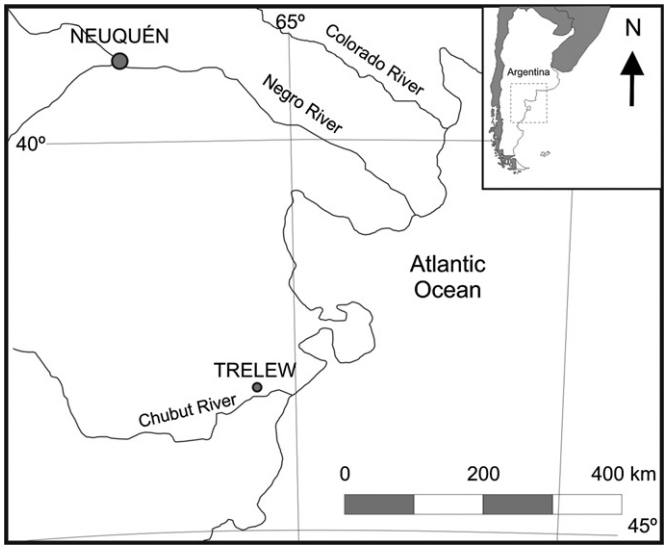

Fig. 1. Study area. This study comprised the area between the lower valleys (~ 100 km inland) of Colorado and Chubut rivers.

Plata, Universidad Nacional de La Plata; and *Museo Etnográfico "Juan B. Ambrosetti" Universidad de Buenos Aires*) evidenced the presence of a characteristic traumatic lesion termed "linear depression" (Gordón, 2011). Additionally, a smaller sample of $n = 189$ skulls from adjacent regions (*i.e.* Pampean and from Northwestern Patagonia) was analyzed for comparative purposes. This paper refers specifically to the sample from Northeastern. The skull sample was subdivided into distinct timeframes on the basis of the presence and kind of artificial deformations of the skull (Barrientos et al., 2009; Bernal et al., 2008; Berón and Baffi, 2003; Berón and Luna, 2009; Favier-Dubois et al., 2007; Gómez Otero and Dahinten, 1997–98; Gordón, 2011; Martínez, 2004). Following a temporal criterion, the sample was subdivided into three periods, namely, >2500 years cal. BP, 2500–1500 years cal. BP, and <1500 years cal. BP. Following a spatial criterion two groups were considered, northern ($n = 436$) (individuals from the surroundings of the lower valleys of Río Colorado and Río Negro), and southern ($n = 361$) (individual from the lower valley of Río Chubut).

Barrientos and Gordón (2004) identified an increase in violence signs through time. However, the late period comprises individuals who lived through the MCA and also those who lived during the first contact with Hispanics, and therefore this increment could have resulted from different stressful situations.

The ultimate objective of this research was to evaluate possible socio-ecological consequences during the late Holocene (Barrientos and Pérez, 2004), and therefore it was necessary to evaluate the frequency of occurrence of evidence for violence in a timeframe that does not include the Hispanic contact period. Even though the frequency of use of various weapons is not always possible to estimate for the all the tools that might have been at play (*e.g.* arrowheads, *boleadoras*, clubs among others), metal weapons were not detected in the area until the mid-1600s (Bechis, 1998).

Bone modifications that arise from different weapons used in Northern Patagonia in times of Hispanic-indigenous contact, were experimentally replicated on recently-slaughtered swine skulls, as a proxy for human skulls. Diagnostic criteria were expected to be obtained through direct observation of the interaction between effectors and traces (*sensu* Gifford-González, 1991) at macro- and microscales. These would then be applied to the study of lesions recorded in human skulls and thus reduce the level of ambiguity in the interpretation of skull traumas.

2. Materials and methods

The experimental design was outlined specifically for the evaluation of a certain type of trauma, *i.e.* linear depressions. For the interpretation of marks on bone remains in those cases where there is no direct association with weapons, an experimental approach is necessary in order to identify the diagnostic characteristics of the marks that are specific for a certain weapon (Lewis, 2008). Experimental studies are well developed in archaeological studies, being more frequent in zooarchaeology, taphonomy and technological studies (Miller et al., 1986; Odell and Cowan, 1986; Pickering and Egeland, 2006; Shipman and Rose, 1984; Walker and Long, 1977). Conversely, this kind of study has not been broadly applied in bioarchaeological research (Lewis, 2008; Smith et al., 2007), where forensic anthropology methods are more commonly used (Chadwick et al., 1999; Karlsson and Stahling, 2000).

Experiments were performed on six swine (*Sus scrofa domestica*) skulls, considered as proxies for human skulls. All individuals were unsexed adults. All soft tissues were preserved, except the skin, which was previously removed; in this way a 3–5 mm layer of muscular mass and connective tissue covered cranial bones. The choice of *Sus scrofa domestica* as an experimental analogue was based on the fact that this species shares a suite of bone and skin characteristics with *Homo sapiens*, which make it useful in comparative studies, mainly of forensic nature (Calce and Rogers, 2007; Daéid et al., 2008; Humphrey and Hutchinson, 2001; Karger et al., 1998; Margulies and Thibault, 2000).

Six original bladed from a private collection (*Colección Pedemonte Méndez*) were used in experimental tests, for being analogous to the ones used in Northern Patagonia during early colonial times. These were:

I- *Briquet* saber, French model 1819, used in Argentina by the Cavalry approximately between 1825 and 1835.
II- French Infantry saber, model 1822, used in Argentina until approximately 1860, with steel blade.
III- First National Army official saber, National Guard Officer saber, Argentinean model 1870, with steel blade. This saber was used by officers during the *Campaña al Desierto* (1878–79), led by War Minister General Julio A. Roca. This represented the culmination of a series of military campaigns in virtue of which the southern frontier of the National State was expanded down to the Río Negro (Bandieri, 2005; Ratto, 2007).
IV- Cavalry saber, Argentinean model 1895, with steel blade. This kind of saber was also used in the *Campaña al Desierto.*
V- Cavalry saber, Argentinean model 1898, with steel blade. This was an official saber used by the Grenadiers and the mounted army divisions.
VI- French saber, model 1890–1900, with steel blade. This saber was used in Chile; its inclusion in this work lies in the fact that it presents similar characteristics to the German saber model 1811 that was widely used in Argentina (Jorge Pedemonte-Méndez, pers. comm.), but was unavailable at the moment of experimentation.

Even though these weapons were used in the area during the 1800s, they were considered to be good analogues to the kind of weapons used previously, given that certain characteristics in the individuals studied (*i.e.* type of cranial deformation, burial site characteristics, radiocarbon dating) placed them in earlier periods (Gordón, 2009b, 2011). In other words, if linear depressions are the product of bladed, it would be reasonable to relate these records to the first stages of aboriginal-colonial contact in Northeastern Patagonia.

Quantitative and qualitative variables of the weapons were registered. The inventory of experimental weapon characteristics made in this study was analogous to a registry based on 35 historic bladed (*i.e.* sabers, swords, bayonets and machetes) from *Museo de Armas de la Nación* (Argentina) (See online supplement).

Swine skulls were placed so that they would have limited movement in relation to the vertical axis (Fig. 2). Experimental skulls did not hang loose at the moment of impact, nor did they remain firmly attached to a substrate; either one of these situations would have differed from a realistic motion produced upon impact of a living individual, yielding trauma patterns different from those intended to be replicated.

Each skull was impacted six times with one of the weapon by the same person (an adult male), so that a total of 36 marks were obtained for statistical analysis. After impact, skulls were cleaned by removing soft tissues and boiling with an enzymatic detergent. Cranial bones were dried at room temperature for 4–7 days.

The terminology proposed by Lewis (see Fig. 1A and B, in Lewis, 2008) was followed for the description of bone lesions.

Macroscopic characteristics of trauma were recorded in the same way that lesions are recorded in archaeological specimens, obtaining linear dimensions for length and minimum and maximum widths. Additionally, qualitative descriptive aspects of the edges, floor and walls of each lesion, the general morphology of the lesion groove in transverse section, and the presence of bone flakes and/or chips (adapted from Lewis, 2008), and the direction of the impact were recorded. Each mark was analyzed with a cool-light stereo microscope (up to 4x magnification), and a hand-held magnifying glass. Linear dimensions were recorded with a millimetric caliper.

In a later stage, individual marks were analyzed with a stereo microscope (Wild Heerbrugg). A set of silicone casts was prepared and analyzed with scanning electron microscopy (Philips SEM, XL Series). With these higher resolution techniques it was also possible to record striations on the walls of individual marks.

In order to compare length and width measurements in experimental and archaeological trauma, student's *t* statistical tests were performed on independent samples. In order to compare frequencies of different qualitative variables related to lesion morphology, homogeneity tests and contingency tables for χ^2 were used. In the case of 2×2 tables, when degrees of freedom were ≤ 1, the data used for the calculation of χ^2 was corrected according to Yates continuity factor (Zar, 1999).

3. Results

Total 36 experimental impacts made upon swine skulls, a sample of 31 bone lesions was obtained, since 5 impacts were absorbed by soft tissues. There was a 13.86% under-representation of experimentally-made bone marks.

Figs. 3 and 4 show median distributions of traumata widths and blade thickness. Fig. 3 shows only experimental cases, while Fig. 4 shows both archaeological and experimental cases (blade thickness refers to the sample of historic weapons from *Museo de Armas de la Nación*). The small range of variation recorded for blade thickness, translated into a relatively large range of dispersion in lesions' widths (Fig. 3). Moreover, in both experimental and archaeological records, blade thickness was more homogeneous in relation to the range of dispersion exhibited by the lesions they produced. On the other hand, in both cases the median of depression widths were slightly smaller than the medians of blade thickness (Fig. 4). This direct association can be made for experimental lesions' widths and blade thickness. The association of these same variables between archaeological records of lesions and blade thickness, revealed from the set of weapons from *Museo de Armas de la Nación* (labeled as "archaeological" in figures), provides an hypothesis used for comparative purposes with experimental results.

Fig. 2. Positioning of swine skulls in order to be impacted.

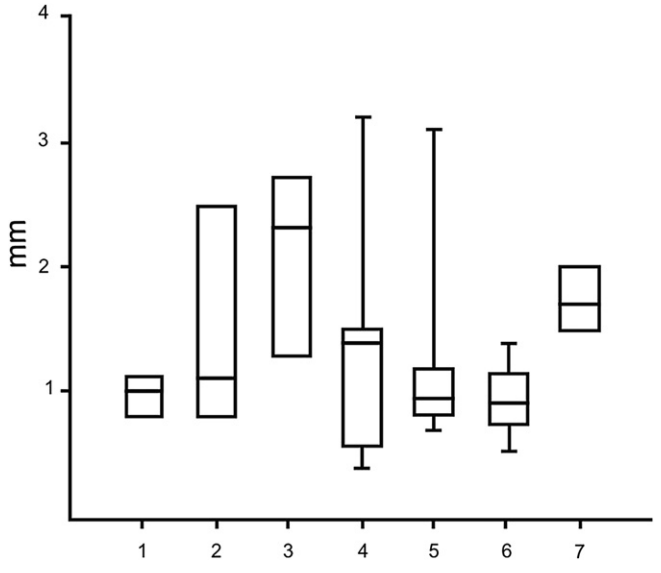

Fig. 3. Median dispersion of traumata widths (experimental skulls 1–6), and blade thickness (7) of experimental weapons.

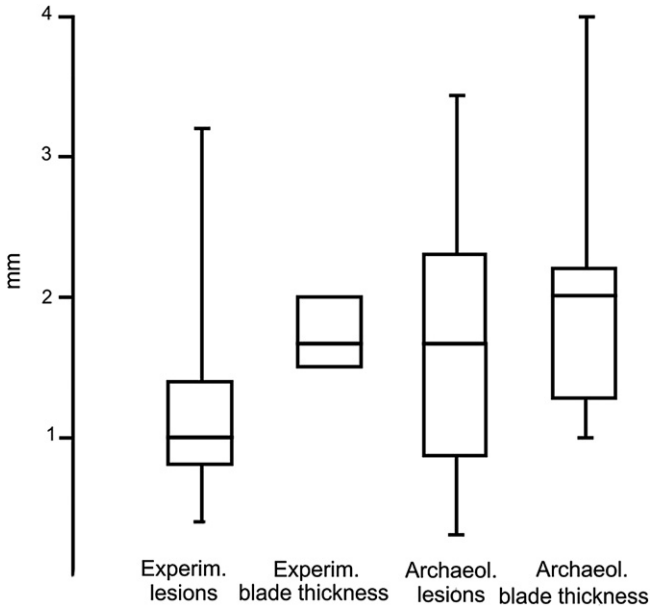

Fig. 4. Median dispersion of traumata widths and blade thickness in experimental and archaeological samples.

Comparing lesion width and length from experimental and archaeological sets, there were no significant differences in mean widths ($p = 0.0680$: although marginally non-significant). Moreover, there were significant differences ($p < 0.0001$) in mean lengths of experimental and archaeological marks. It is worth mentioning that experimental lesions which were made with long blades, presented a mean length of 24.21 mm, which coincides with the range of 22.9–24.2 mm observed by Lewis (2008). Moreover, the mean length value from lesions caused by knife presented by this author (12.7 mm) is similar to the mean length of archaeological lesions (12.9 mm). In this sense, taking into account metric variables and regardless of a direct association, it is worth mentioning that the lesions were probably made with a different metallic bladed.

Table 1 sums up qualitative variables. Macroscopically, none of the variables considered showed significant differences, thus describing similar morphological traits, and therefore validating the null hypothesis that implies that the proportions of the different categories are homogeneously distributed between the two sets of samples. Figs. 5 and 6 show archaeological and experimental marks photographed at a macroscopic scale. Results of such a macroscopic analysis have been previously presented in Gordón (2009b).

Tables 2 and 3 present analogous information regarding observations made at higher magnifications, with a stereo microscope and with SEM, respectively. The higher resolution of these methods enabled the analysis of two additional traits, *i.e.* presence and direction of striations. The lesion frequencies compared herein vary according to the technique used, since some marks could not be thoroughly analyzed at lower magnifications. Those lesions in which most of the variables listed in Tables could be analyzed, were selected. Figs. 7 and 8 show archaeological and experimental marks photographed under the stereo microscope, while in Figs. 9 and 10 they are photographed with SEM.

No significant differences between archaeological and experimental lesions were observed for any of the variables (Tables 2 and 3), regardless of the magnification of the analysis. This suggests that archaeological linear depressions correspond to weapons of the same characteristics as those used experimentally.

Table 1
Qualitative variables considered for experimental and archaeological marks in macroscopic scale. Frequencies and *p*-values for the χ^2 statistic.

	Experimental cutmarks ($n = 29$)	Archaeological cutmarks ($n = 51$)	*p*
Regularity of the edges			
Both regular	7	9	0.4508
Both irregular	5	15	
One regular and one irregular	17	27	
Regularity of floor			
Regular	23	39	0.6496
Irregular	3	6	
Non-visible	3	6	
Regularity of the walls			
Both regular	7	9	0.6926
Both irregular	5	12	
One regular and one irregular	17	30	
Morphology of the groove section			
V-shape	17	27	0.8867
U-shape	9	18	
Non-visible	3	6	
Damage to the sides			
Both damaged	7	9	0.2086
Undamaged	9	9	
One-side damaged	13	33	
Presence of flakes/chips			
Flakes ($\geq$2 mm)	11	21	0.1963
Chips ($<$2 mm)	4	15	
Flakes and chips present	8	6	
None	6	9	
Directionality of the impact			
At an angle ($>$ or $<$ 90°) to the surface	13	15	0.2519
Perpendicular ($\sim$90°) to the surface	16	36	

4. Discussion and final remarks

To begin with, a discussion of results from archaeological evidence is necessary, regardless of it not being the main objective of this paper. The variables considered and their percentual representation in samples were: a) linear fractures (21%) and hollow marks (4%); b) linear (25.4%) and sub-circular depressions (30%); c) perforations with (1.6%) and without inclusions (10.3%); and d) simple (2%) and tangential cutmarks (3.2%). A higher percentage of lesions were on an front (34.8%) and superior (26.3%) views. Even though there were no significant differences between sexes, there was a tendency for females to present a higher proportion of front view lesions. The percentage of lesions with

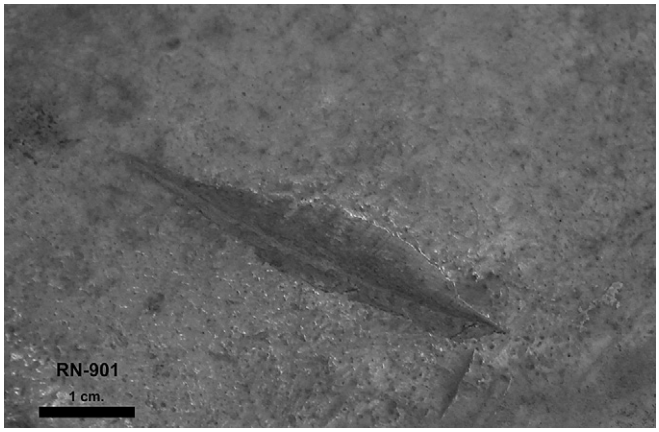

Fig. 5. Archaeological linear depressions. Ind. 910 (*Museo de La Plata*). Reference: RN: lower Río Negro valley.

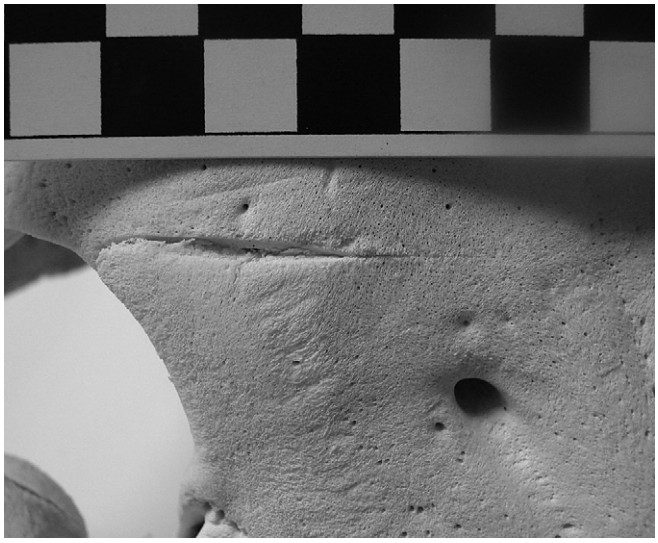

Fig. 6. Experimental linear depressions. Experimental skull No. 2.

evidences of healing was higher in the Southern group (26.5%) when compared to the Northern one (14.16%).

Determining violence signs in archaeological samples can be ambiguous. Therefore we implemented two levels of analysis. The first level considered all wounds that could have been the product

Table 2
Qualitative variables considered for experimental and archaeological marks observed under stereo microscope. Frequencies and *p*-values for the χ^2 statistic.

	Experimental cutmarks ($n = 25$)	Archaeological cutmarks ($n = 45$)	*p*
Regularity of the edges			
Both regular	5	12	0.3678
Both irregular	3	10	
One regular and one irregular	17	23	
Regularity of floor			
Regular	13	30	0.4170
Irregular	6	9	
Non-visible	6	6	
Regularity of the walls			
Both regular	3	4	0.2020
Both irregular	3	14	
One regular and one irregular	19	27	
Morphology of the groove section			
V-shape	12	25	0.8309
U-shape	9	14	
Non-visible	4	6	
Damage to the sides			
Both damaged	1	9	0.1583
Undamaged	7	13	
One-side damaged	17	23	
Presence of bone flakes chips			
Flakes ($\geq$2 mm)	15	28	0.1508
Chips ($<$2 mm)	2	1	
Flakes and chips present	6	5	
None	2	11	
Directionality of the impact			
At an angle ($>$ or $<$ 90°) to the surface	10	15	0.7661
Perpendicular ($\sim$90°) to the surface	15	30	
Striations			
Present	9	17	1.0000
Absent	16	28	
Directionality of striations			
Parallel to the main axis	8	10	0.2569
Transverse or oblique to the main axis	1	7	

Table 3
Qualitative variables considered for experimental and archaeological marks observed with scanning electron microscopy. Frequencies and *p*-values for the χ^2 statistic.

	Experimental cutmarks ($n = 9$)	Archaeological cutmarks ($n = 10$)	*p*
Regularity of the edges			
Both regular	2	2	0.1977
Both irregular	5	2	
One regular and one irregular	2	6	
Regularity of floor			
Regular	4	9	0.1013
Irregular	5	1	
Non-visible	0	0	
Regularity of the walls			
Both regular	0	1	0.2166
Both irregular	5	2	
One regular and one irregular	4	7	
Morphology of the groove section			
V-shape	8	9	1.0000
U-shape	1	1	
Non-visible	0	0	
Damage to the sides			
Both damaged	2	1	0.5194
Undamaged	2	1	
One-side damaged	5	8	
Presence of flakes/chips			
Flakes ($\geq$2 mm)	1	5	0.0542
Chips ($<$2 mm)	4	0	
Flakes and chips present	2	4	
None	2	1	
Directionality of the impact			
At an angle ($>$ or $<$ 90°) to the surface	5	3	0.5085
Perpendicular ($\sim$90°) to the surface	4	7	
Striations			
Present	4	9	0.1013
Absent	5	1	
Directionality of striations			
Parallel to the main axis	4	3	0.1047
Transverse or oblique to the main axis	0	6	

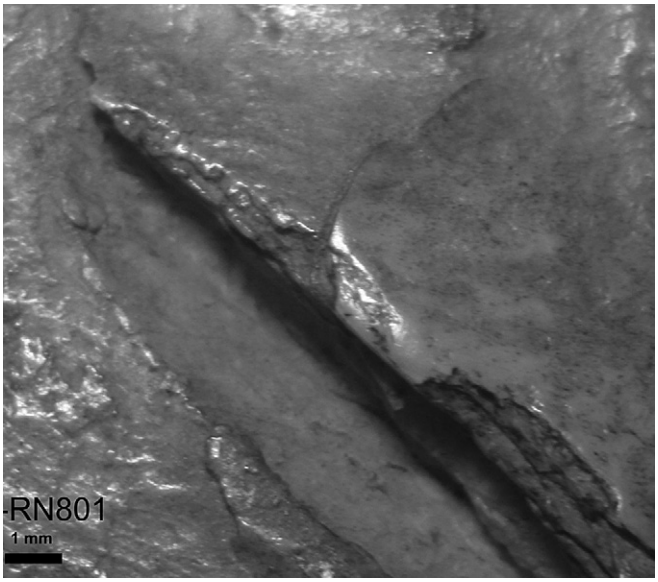

Fig. 7. Archaeological linear depressions observed under stereo microscope (10 ×–10 × 1.5). References: RN: lower Río Negro valley.

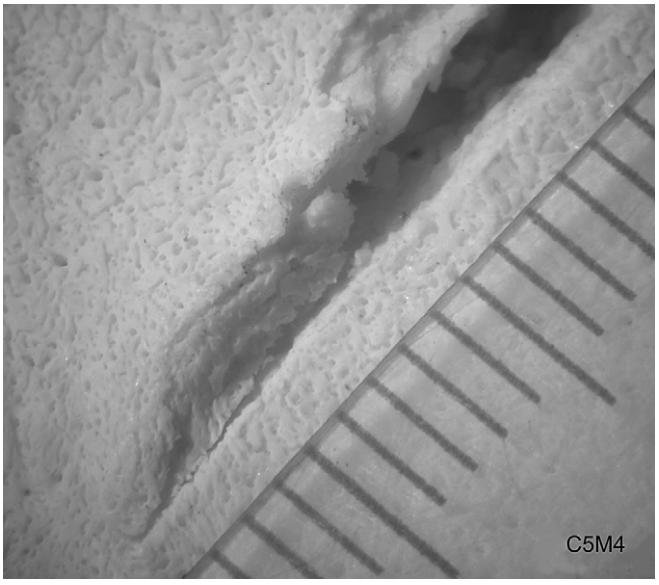

Fig. 8. Experimental linear depressions observed under stereo microscope (10 × 0.6–10 × 1.8). References: C: skull number; M: mark number.

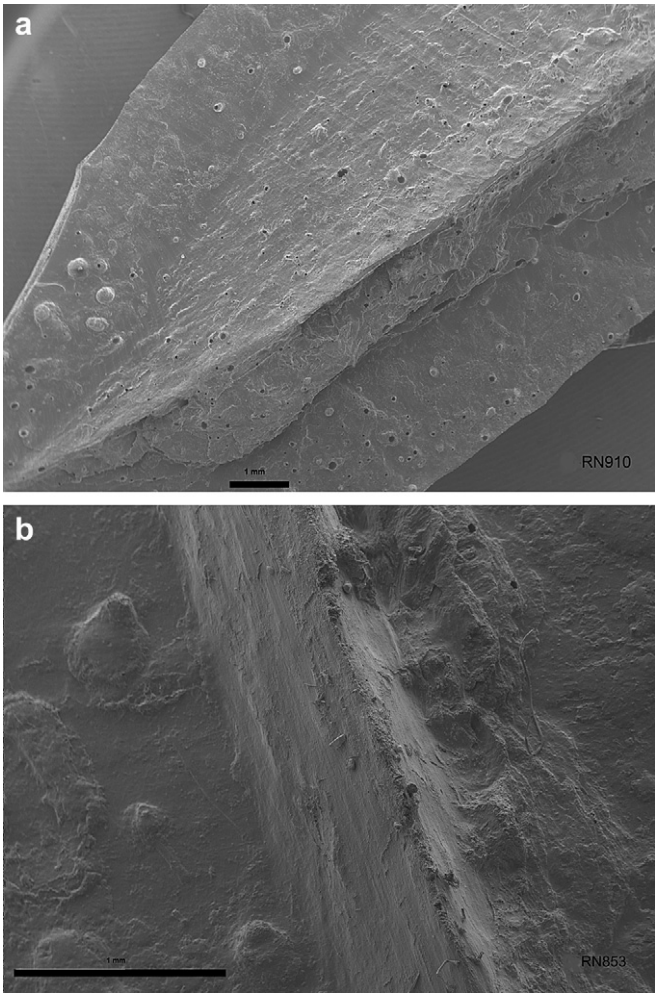

Fig. 9. Silicone cast of archaeological linear depressions observed with SEM (magnification 9-70 ×). Reference: RN: lower Río Negro valley.

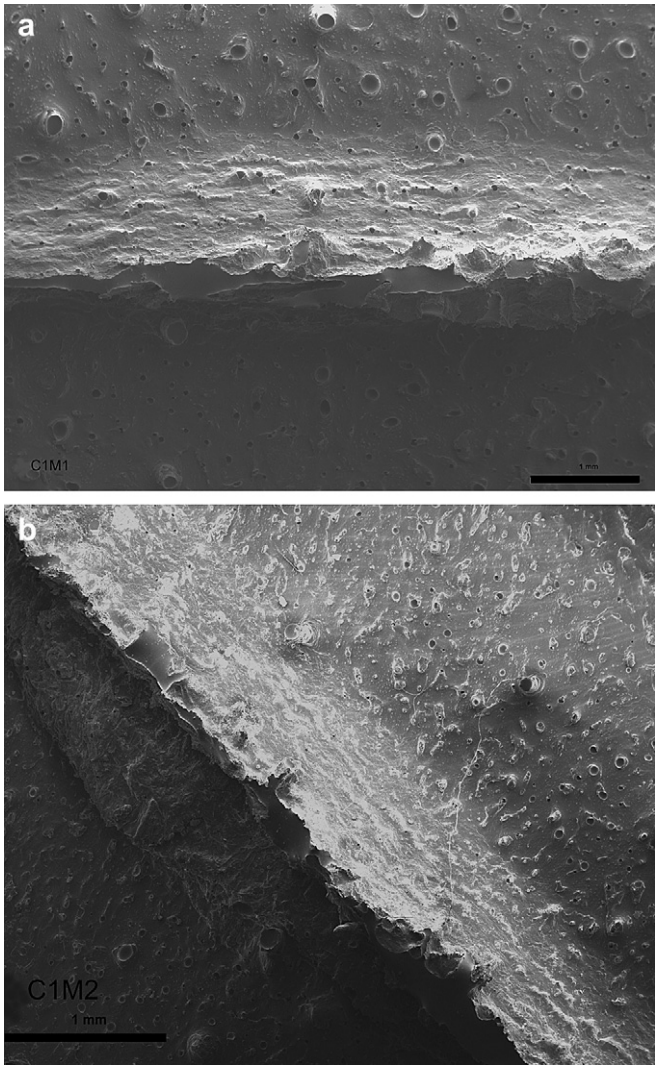

Fig. 10. Silicone cast of experimental linear depressions, observed with SEM (magnification 9-70 ×). References: C: skull number; M: mark number.

of violence, although not necessarily so (*e.g.* healed fractures). The second level strictly considered those cases with low or no ambiguity (*e.g.* incrusted arrowheads, lesions with associated fractures, multiple lesions).

Individuals from the Northern group were more affected by violent situations than those from the Southern group [95/436 and 48/361, respectively for the first analysis level ($p = 0.0025$); and 19/436 and 8/361, respectively for the second analysis level ($p = 0.1424$)]. There were significant differences between sexes in the Northern group (level 1: $p = 0.0103$; level 2: $p = 0.0110$), with a higher incidence in males. Conversely, there were no significant differences between sexes in the Southern group. Males in the Northern group presented significantly higher frequencies than males in the Southern group in the second level ($p = 0.0296$). In diachronous perspective, the Northern group presented a significant difference in the first level ($p = 0.0556$), and a highly-significant difference in the second one ($p = 0.0098$). The Southern group presented no significant differences. Regarding sexes, the only diachronous difference observed was for Northern males at the second level ($p = 0.0383$).

The experimental approach evidenced that these types of traumata (*i.e.* linear depressions) probably correspond to metal

weapons, and therefore should be related to the moment of first colonial contact. From these preliminary observations, the data were re-analyzed without considering human skulls with this kind of lesions, so that the frequency of those lesions most common during the MCA were not overestimated. This new analysis evidenced significant spatial differences for the first level of analysis, with higher lesion frequencies in the northern group (*i.e*. the one from the lower basins of Colorado and Negro rivers) ($p = 0.0069$). This suggests that certain relationships among populations were established previously to the arrival of Europeans in the region. From a diachronic perspective, even though the tendency shows an increase in the level of violence, no significant differences were detected. Moreover, it was not possible to evidence a previously-detected difference between males from northern and southern groups (higher in the former).

Therefore, the experimental approach used in this study demonstrated that linear depressions are the product of metal weapons, which were not present in the area until the first half of the 17th century. This result is of paramount importance, in that it debunks the previously held hypothesis that linked environmental modifications occurred during the MCA with an increase in the levels of social tension, and eventually violence.

It is noteworthy that the experimental approach presented in this work has far-reaching implications for bioarchaeological research, leading to the reformulation of certain long-held ideas. Firstly, it is fundamental to carry on with paleoenvironmental studies at local and meso-regional scales, so that new evidence is gathered on how and to what extent the modifications created by the MCA impacted this area. On the other hand, demographic expansion and dispersion processes from Northern Patagonia into the Southeastern Pampean region (Barrientos and Pérez, 2004) need a more thorough analysis, for being complementary to, even if they exceed the objectives of the present study. In that sense, if a demographic nucleation is assumed for the most productive areas, such as the lower basins of large rivers and the Atlantic shoreline, and if such nucleation potentially created social tension, this did not translate into unprecedented higher levels of violence. Therefore, it is reasonable to think that other mechanisms were at play in the dissipation of such social tensions. In this context, other demographic mechanisms (*e.g.* migrations, group fission and fusion), and the creation of alliances for the exchange of goods, people and information, might have taken place (Martínez 2008–09; Martínez et al., 2006, 2009; Stoessel, 2007; Prates, 2008). Moreover, the Río Colorado basin has been pointed out as being a "soft frontier", *i.e.* a territory inhabited and shared by several groups with flexible dynamics (Curtoni, 2004).

The evidence of violence throughout the temporal sequence studied, with no significant increments until the first stages of Hispanic-indigenous contact, suggests that this behavior can be interpreted in terms of evolutionary and adaptive processes inherent to the populations, as a necessary mechanism for the maintenance and strengthening of social links (De Waal, 2000; Gordón, 2011; Keeley, 1996; among others).

In conclusion, the experimental approach of this study was of paramount importance in the discrimination of bone marks produced by metal objects. This led to reconsideration from different perspectives, of the implications of a broader topic, currently underway.

Acknowledgments

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Appendix. Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jas.2011.10.023.

References

Bandieri, S., 2005. Historia de la Patagonia. Editorial Sudamericana, Buenos Aires.
Barrientos, G., 1997. Nutrición y dieta de las poblaciones aborígenes prehispánicas del sudeste de la región pampeana. Ph.D. Dissertation, Universidad Nacional de La Plata, Facultad de Ciencias Naturales y Museo, La Plata.
Barrientos, G., Béguelin, M., Gordón, F., 2009. Tendencias cronológicas en el registro bioarqueológico del Noreste de Patagonia. Abstracts from the IX Jornadas Nacionales de Antropología Biológica, pp. 96. Puerto Madryn.
Barrientos, G., Gordón, F., 2004. Explorando la relación entre nucleamiento poblacional y violencia interpersonal durante el Holoceno tardío en el noreste de Patagonia (República Argentina). Magallania 32, 53–69.
Barrientos, G., Pérez, I., 2004. La expansión y dispersión de poblaciones del norte de Patagonia durante el Holoceno tardío: evidencia arqueológica y modelo explicativo. In: Civalero, T., Fernández, P., Guraieb, G. (Eds.), Contra Viento Y Marea. Arqueología de la Patagonia, Buenos Aires, pp. 179–195.
Bechis, M., 1998. Prólogo. In: Nacuzzi, L.R. (Ed.), Identidades Impuestas. Tehuelches, Aucas y Pampas en el Norte de la Patagonia. Sociedad Argentina de Antropología, Buenos Aires, pp. 9–14.
Bernal, V., González, P.N., Pérez, S.I., Pucciarelli, H.M., 2008. Entierros humanos del noreste de Patagonia: nuevos fechados radiocarbónicos. Magallania 36 (2), 125–134.
Berón, M.A., Aranda, C., Luna, L., 2007. Variabilidad y tendencias temporales de las prácticas mortuorias en el sitio Chenque. Expanded abstracts from XVI Congreso Nacional de Arqueología Argentina, San Salvador de Jujuy, pp. 247–253.
Berón, M., Baffi, I., 2003. Procesos de cambio cultural en los cazadores- recolectores de la provincia de La Pampa, Argentina. Intersecciones en Antropología 4, 29–43.
Berón, M., Luna, L., 2009. Distribución espacial y cronológica de la deformación craneana tabular erecta en Pampa y Norpatagonia. In: Salemme, M., Santiago, F., Álvarez, M., Piana, E., Vázquez, M., Mansur, E. (Eds.), Arqueología de Patagonia: una mirada desde último confín. Editorial Utopías, Ushuaia, pp. 561–575.
Bettinger, R.L., Baumhoff, M.A., 1982. The Numic Spread: Great basin cultures in competition. American Antiquity 47, 485–503.
Calce, S.E., Rogers, T.L., 2007. Taphonomic changes to blunt forcé trauma: a preliminary study. Journal of Forensic Science 52 (3), 519–527.
Chadwick, E.K.J., Nicol, A.C.J., Lane, V., Gray, T.G.F., 1999. Biomechanics of knife stab attacks. Forensic Science International 105, 35–44.
Constantinescu, F., 2003. Obsidiana verde incrustada en un cráneo Aónikenk: ¿tensión social intraétnica…o interétnica? We`ll never know! Magallania 31, 149–153.
Curtoni, R., 2004. Territorios y territorialidad en movimiento: la dimension social del paisaje. Etnía 46–47, 87–104.
Daéid, N.N., Cassidy, M., Mchugh, S., 2008. An investigation into the correlation of knife damage in clothing and the lengths of skin wounds. Forensic Science International 179, 107–110.
De Waal, F.B.M., 2000. Primates – A natural Heritage of conflict resolution. Science 289, 586–590.
Favier-Dubois, C., García Guraieb, S., Borella, F., Mariano, C., 2007. Primeros avances acerca del registro bioarqueológico de la costa rionegrina. Expanded Abstracts from XVI Congreso Nacional de Arqueología Argentina. San Salvador de Jujuy, Tomo III, pp. 359–364.
Flensborg, G., 2011. Lesiones traumáticas en cráneos del sitio Paso Alsina 1. Explorando indicadores de violencia interpersonal. Intersecciones en Antropología 12, 155–166.
García Guraieb, S., Goñi, R., Bosio, L., 2007. Lesiones traumáticas en un entierro del lago Salitroso (Santa Cruz, Argentina). In: Morello, F., Martinic, M., Prieto, A., Bahamonde, G. (Eds.), Arqueología de Fuego-Patagonia. Levantando piedras, desenterrando huesos… y develando arcanos. Ediciones CEQUA, Punta Arenas, Chile, pp. 375–380.
Gifford–González, D.P., 1991. Bones are not enough: analogues, knowledge, and interpretive strategies in zooarchaeology. Journal of Anthropological Archaeology 10, 215–254.
Gómez Otero, J., Dahinten, S., 1997/1998. Costumbres funerarias y esqueletos humanos: variabilidad y poblamiento en la costa nordeste de la provincia de Chubut (Patagonia Argentina). Relaciones de la Sociedad Argentina de Antropología (N.S.) 22–23, 101–124.

Goñi, R.A., 1983/1985. Sitios de ocupación indígena tardía en el Departamento Picunches (Provincia del Neuquén, Argentina). Cuadernos del Instituto Nacional de Antropología 10, 363–386.
Goñi, R.A., 1986/1987. Arqueología de sitios tardíos en el valle del río Malleo, provincia del Neuquén. Relaciones de la Sociedad Argentina de Antropología (N.S.) 17, 37–66.
Gordón, F., 2009a. El estudio de la violencia en sociedades de pequeña escala. Bases conceptuales para la construcción de modelos aplicables a casos arqueológicos. In: Bourlot, T., Bozzuto, D., Crespo, C., Hecht, A.C., Kuperszmit, N. (Eds.), Entre Pasados y Presentes II. Estudios Contemporáneos en Ciencias Antropológicas. Editorial Fundación de Historia Natural Félix de Azara, Buenos Aires, pp. 113–126.
Gordón, F., 2009b. Atribución causal a traumas craneofaciales en muestras del norte de Patagonia (República Argentina): una perspectiva experimental. Magallania 37 (2), 57–76.
Gordón, F., 2009c. Tafonomía humana y lesiones traumáticas en colecciones de museos. Evaluación de cráneos del noreste de Patagonia. Intersecciones en Antropología 10, 27–41.
Gordón, F., 2011. Dinámica Poblacional, Conflicto y Violencia en el Norte de Patagonia durante el Holoceno tardío: un Estudio Arqueológico. Ph.D. Dissertation, Universidad Nacional de La Plata, La Plata. 345 pp.
Gordón, F., Ghidini, G., 2006. Análisis bioarqueológico de la violencia interpersonal. El valle inferir del río Negro (República Argentina) durante el Holoceno tardío. Revista Werken 9 (2), 27–45.
Humphrey, J.H., Hutchinson, D.L., 2001. Macroscopic characteristics of hacking trauma. Journal of Forensic Science 46, 228–233.
Karger, B., Sudhues, H., Kneubuehl, B.P., Brinkmann, B., 1998. Experimental arrow wounds: ballistics and traumatology. Journal of Trauma-Injury Infection & Critical Care 45 (3), 495–501.
Karlsson, T., Stahling, S., 2000. Experimental blowgun injuries, ballistic aspects of modern blowgun. Forensic Science International 112, 59–64.
Keeley, L.H., 1996. War Before Civilization. Oxford University Press, New York.
L'Heureux, G.L., Amorosi, T., 2009. El entierro 2 del sitio Cañadón Leona 5 (Región de Magallanes, Chile). Viejos huesos, nuevos datos. Magallania 37 (2), 41–55.
Lambert, P., 1997. Patterns of violence in prehistoric hunter-gatherers societies of coastal southern California. In: Martin, D.L., Frayer, D.W. (Eds.), 1997. Troubled Times: Violence and Warfare in the Past. War and Society, vol. 6. Gordon and Breach Publishers, Amsterdam, pp. 77–109.
Lambert, P., 2002. The archaeology of war: a North American perspective. Journal of Archaeological Research 10 (3), 207–241.
Lewis, J.E., 2008. Identifying sword marks on bone: criteria for distinguishing between cut marks made by different classes of bladed weapons. Journal of Archaeological Science 35 (7), 2001–2008.
Margulies, S.S., Thibault, K.L., 2000. Infant skull and suture properties: measurements and implications for mechanisms of pediatric brain injury. Journal of Biomechanical Engineering 22 (4), 364–371.
Martínez, G., 2004. Resultados preliminares de las investigaciones arqueológicas realizadas en el curso inferior del río Colorado (Partidos de Villarino y Patagones, Pcia. de Buenos Aires). In: Martínez, G., Gutierrez, M., Curtoni, R., Berón, M., Madrid, P. (Eds.), Aproximaciones Arqueológicas Pampeanas: Teorías, Métodos y Casos de Aplicación Contemporáneos. FACSO-UNCPBA, Olavarría, pp. 275–292.
Martínez, G., 2008/2009. Arqueología del curso inferior del río Colorado: estado actual del conocimiento e implicaciones para la dinámica poblacional de cazadores-recolectores pampeano-patagónicos. Cazadores Recolectores del Cono Sur. Revista de Arqueología 3, 71–92.
Martínez, G., Bayala, P., Flensborg, G., López, R., 2006. Análisis preliminar de los entierros humanos del sitio Paso Alsina 1 (Pdo. de Patagones Pcia. de Buenos Aires). Intersecciones en Antropología 7, 95–108.
Martínez, G., Zangrando, A.F., Prates, L., 2009. Isotopic ecology and human palaeodiets in the lower basin of the Colorado River, Buenos Aires Province, Argentina. International Journal of Osteoarchaeology 19, 281–296.
Miller, R., McEwen, E., Bergman, C., 1986. Experimental approaches to ancient near eastern archery. World Archaeology 18 (2), 178–195.
Milner, G., 1995. An osteological perspective on prehistoric warfare. In: Beck, L.A. (Ed.), Regional Approaches to Mortuary Analysis. Plenum Press, New York, pp. 221–244.
Odell, G.H., Cowan, F., 1986. Experiments with spears and arrows on animals targets. Journal of Field Archaeology 13 (2), 195–212.
Pickering, T.R., Egeland, C.P., 2006. Experimental patterns of hammerstone percussion damage on bones: implications for inferences of carcass processing by humans. Journal of Archaeological Science 33, 459–469.
Prates, L. 2008. Los Indígenas del Río Negro. Un enfoque Arqueológico. Sociedad Argentina de Antropología, Colección Tesis Doctorales, Buenos Aires.
Ratto, S., 2007. Indios y Cristianos. Entre la Guerra y la Paz en las Fronteras. Editorial Sudamericana, Buenos Aires.
Scabuzzo, C., 2010. Actividades, patologías y nutrición de los cazadores recolectores pampeanos. Ph.D. Dissertation, Universidad Nacional de La Plata, Facultad de Ciencias Naturales y Museo, La Plata.
Shipman, P., Rose, J.J., 1984. Cutmark mimics on modern and fossil bovid bones. Current Anthropology 25 (1), 116–117.
Smith, M.J., Brickley, M., Bleach, S.L., 2007. Experimental evidence for lithic projectile injuries: improving identification of an under-recognized phenomenon. Journal of Archaeological Science 34, 540–553.
Stine, S., 1994. Extreme and persistent drought in California and Patagonia during mediaeval time. Nature 369, 546–549.
Stine, S., 2000. On the Medieval Climatic Anomaly. Current Anthropology 41, 627–628.
Stoessel, L., 2007. Análisis arqueofaunísticos de los sitios Loma Ruíz 1 y El Tigre (Partidos de Villarino y Patagones, provincia de Buenos Aires). Aportes para el conocimiento de la subsistencia en el valle inferior del río Colorado durante el Holoceno tardío. Intersecciones en Antropología 8, 235–251.
Vignati, M.A., 1947. Contribuciones al conocimiento de la paleopatología argentina I-XIII. Notas del Museo de La Plata 36–48, 19–81.
Walker, P.L., 1989. Cranial injuries as evidence of violence in prehistoric southern California, Santa Barbara. American Journal of Physical Anthropology 80, 313–323.
Walker, P.L., 2001. A bioarchaeological perspective on the history of violence. Annual Review of Anthropology 30, 573–596.
Walker, P.L., Long, J.C., 1977. An experimental study of the morphological characteristics of tool marks. American Antiquity 32 (4), 605–616.
Zar, J.H., 1999. Biostatistical Analysis. Prentice Hall, Illinois.