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Authors' Response

Sir:

How big is big enough? Sample size and the uniqueness of the dentition.

Dr. Bowers raises issues about the untestability of bitemark applications and sample size, and how they bear on the presumed uniqueness to the human anterior dentition. These are issues that are well worth wrestling with. Bowers sympathizes with our view that bitemark analysis rests on two foundational assumptions, but thinks we failed to address the reliable transference of this uniqueness to resulting bitemarks on bruised skin. We fully agree.

He then highlights four areas of concern; first, that our study ignores the three dimensional nature of the teeth: second, that our study uses a sample to draw conclusions about the dental uniqueness and that our sample size is too small; third, that we failed to mention a 3D laser study of 42 study models that demonstrated high error rates; and finally, that "Procrustes analysis is another anecdotal analysis."

We will begin by observing that our study was focused solely on 2D data. Obviously 2D data are not fully representative of the dentition since teeth are 3D structures. The selection of variables always implies the reduction of information about the complex morphological structures to generate a model of their form. We consider that the set of landmarks and semilandmarks selected summarizes the relevant features to describe the occlusal surface of anterior dental arcade (i.e., general changes in its length and width, and tooth orientation). Our results show that even though the variation is summarized in a low dimensionality there is a high differentiation among individuals. Taking this into account, the inclusion of information about dental form by incorporating 3D data will yield to a greater separation among individuals. Moreover, the sample analyzed displays a lower level of individuality than the expected in the general population, because only individuals with post-orthodontic normocclusion and unrestored teeth were selected. In conclusion, though the morphology was captured with 2D data and the individuals display greater homogeneity due to the treatment, our study did not find two individuals with identical anterior dental arcades. Finally, we do not think that appealing to dimensional data of the anterior dentition violates any legitimate prohibitions about inference—after all, the literature is replete with articles distinguishing human populations and fossils on the basis of 2D dental measurements.

We will answer the "make use of samples" issue by saying that sampling is a standard procedure in science. Because most times it is not feasible obtain data of the entire population, scientific knowledge is based on information obtained from samples, which is used to draw conclusions about the populations from which the samples were taken (1). Likewise, dental researchers are acutely aware of sample-size problems, simply because craniofacial studies are complex and often involve many variables. This question has plagued researchers who are often reminded that statistical uncertainty decreases as sample size increases. We feel that our sample size is adequate for the comparison of continuous measures (see for instance, 2). This does not mean that we favor probabalism, in the sense that the statistical calculation of a probability cannot serve as an account of the supportiveness of evidence in court. Rather, supportiveness of evidence is dependent on incremental explanatory integration of evidence (for discussion, see 3).

In relation to the use of Procrustes analysis to study biological form, we think that this is not simply "another anecdotal analysis". In 1980s, the field of morphometric studies experienced a paradigm shift (1,4). This shift involved a more comprehensive description and quantification of morphological structures than traditional morphometrics (5) based on linear distance measurements by emphasizing methods that capture the geometry of the morphological structures of interest, and preserving this information throughout the analyses (4). In this context, shape is defined as the information remaining in a configuration of points after the differences due to location, scale and orientation are removed. Procrustes analysis is an important procedure because it is typically removes variation in digitizing location, orientation, and scale, and superimposes the objects in a common coordinate system (6). This method has developed into a rigorous statistical theory for shape and makes possible the application of multivariate statistical methods and methods for the direct visualization of biological form (7). The aligned specimens from Procrustes analysis provide points that can be projected into a space that is tangent to Kendall's shape space (7–9). In this linear tangent space, distances between pairs of points (specimens) approximate the Procrustes distances between the corresponding pairs of landmark configurations.

In summary, we thank Dr. Bowers for raising some important issues surrounding bitemark analysis, but in addressing all of these, we remain convinced that our analysis does point to the uniqueness of the human anterior dentition.

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