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# New method to validate FEA on palaeobiological modeling

**Alejandro Perez-Ramos[1], Miquel De Renzi[1] and Josep Fortuny [2]**

[1]Cavanilles Institute, University of Valencia. c/Catedrático José Beltrán 2. 46980 Valencia, Spain.
pera@alumni.uv.es, miquel.de.renzi@uv.es
[2]Institut Català de Paleontologia Miquel Crusafont, Modul ICP Facultat de Biociencies, Universitat Autònoma de Barcelona, 08193, Cerdanyola del Vallés, josep.fortuny@icp.cat

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Biomechanical models generated by finite element analysis (FEA) should be subjected to several processes for their optimization. The general procedure starts from a computed tomography (CT) of the sample in order to obtain a pile of gray scale slices. The next steps include the generation of a 3D model using CT software, and a preprocessing of the model with CAD software to finally obtain an optimal model that can be imported to the FEA software. However, these steps could be subjected to a large amount of experimental and computational error, and therefore, biomechanical results could be biased. To solve these difficulties and errors, herein we propose a new method to validate the FEA results using the Giant Chinese Salamander (*Andrias davidianus*) as case study. The procedure starts with the CT slices in combination with the image analysis software *ImageJ* to obtain the distribution patterns of local thickness using the plugin *Local_Thickness*, and then to apply a complex pattern analysis of the models generated by *Local_Thickness* from *ImageJ* (fig. 1A) and by any kind of FEA software (fig. 2A). In order to analyze the complexity of fractality and lacunarity patterns, the plugin *FracLac* (*ImageJ*) should be applied to binary images of both models (figs. 1B and 2B). The results obtained from both analysis should be tested statistically to conclude if differ or not (Table and graphic). Thus, this technique assesses the fit of our models generated by FEA in relation to the real model of the specimen under study.

Figures

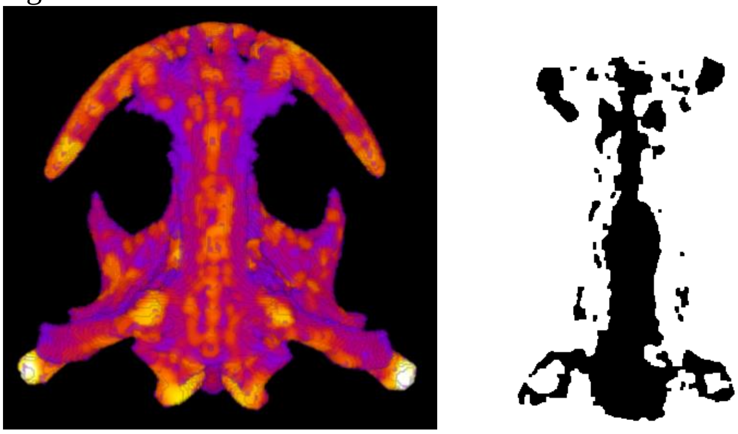


Fig. 1A.Thickness model of *Andrias davidianus*. Colorimetric scale: Light colors, maximum thickness and blue color minimum thickness. (Left image) Fig. 1B. Binary model of *Andrias davidianus*: Representation of thickness pattern corresponding to the zone of deformation by biomechanical strain in the FEA model. (Right image).

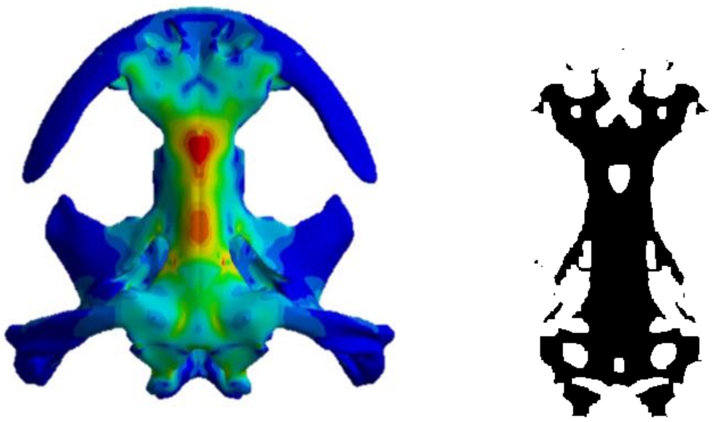
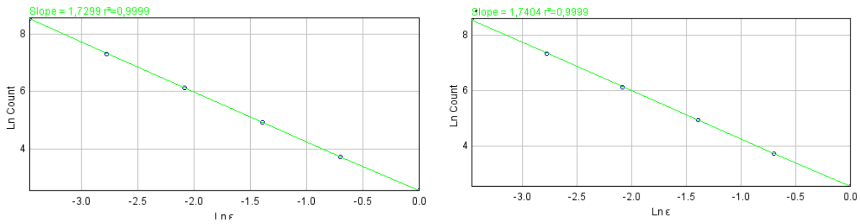


Fig. 2A. FEA model of *Andrias davidianus*. Colorimetric scale: red, maximum strain and blue, minimum strain. (Left image) Fig.2B. Binary model of *Andrias davidianus*: Representation of pattern corresponding to the zone of deformation by biomechanical strain in the FEA model. (Right image).

| | Size Box | Df | S.E | Lacunarity | S.E |
|---|---|---|---|---|---|
| Andrias_Thk | (2, 4, 6, 8, 16, 32, 64) | 1,7299 | 0,0178 | 0,3177 | 0,0689 |
| Andrias_FEA | (2, 4, 6, 8, 16, 32, 64) | 1,7404 | 0,0277 | 0,2552 | 0,0298 |

**Table.** Statistical results. The thickness model and FEA model present significant same values of Fractal dimension (Df) and Lacunarity demonstrating that FE analysis was successfully performed. **Andrias_Thk** (Thickness model of Andrias, box_counting method to apply this binary model); **Andrias_FEA** (FEA model of Andrias, box_counting method to apply this binary model); **Size Box** (number of base_2 logarithm used in each size box); **Df** (fractal dimension: spatial complexity index); **S.E** (standar error of the regression line of box_counting); **Lacunarity** (spatial texture index).

## Graphics on the regression line of box_counting




(Left Image). Regression line of binary local thickness model to apply method box_counting. (Right image). Regression line of binary FEA model. The two regression lines have the same set points on the line and the same slope.