Introduction

Combining exceptionally preserved fossils with computational modelling has allowed palaeontologists to reconstruct entire bodies of extinct animals, most notably dinosaurs from full skeletons [1,2].

Extinct sharks, however, have particularly poor preservation due to their cartilaginous skeletons – with only hard teeth and occasional vertebral preserved.

In the case of the extinct giant shark, *Odontaspis megalodon* (Mioce–Pliocene), the Great White Shark (GWS) (*Carcharodon carcharias*) is considered the best available ecological analogue [3–5].

Moreover, jaws have been reconstructed and a vertebral column (IRSNB 3121/9883) of ~150 vertebrae was discovered in Belgium in 1926 [3].

Here, we use CT scans of this exceptional vertebral column, and of the GWS, to create the first ever 3D computational model of *O. megalodon*, the largest macropredatory shark that ever lived.

Materials and methods

- *O. megalodon* teeth and vertebral were measured directly at the Royal Belgian Institution of Natural Sciences.
- Crown height (CH) of A2 teeth were used to calculate possible TL of our model based on previously published equations [6].
- Jaw reconstruction & vertebral column were CT scanned, imported into Blender [7], and scaled to real size based on measurements of the vertebral column (~155 mm diameter for largest centrum).
- A CT scanned GWS skull from a previous study [8] was added to the column, and the flesh was recreated with an octagonal hooping method previously used in dinosaur reconstructions [1,2].
- This hooping method was repeated around the body and individual fins of a full body scan of a GWS (3.35 m TL) scaled up to fit the spinal column from head to fork.

Results

- When scaled to real size, the vertebral column is revealed to be ~11.1 m long, significantly longer than a previously calculated TL for the shark this column came from [3].
- CH-TL calculations suggest a shark of ~13.87 m TL (Table 1), but the completed model measures as ~15.93 m TL, a size deemed to be exceptionally large for *O. megalodon* [6].
- Computing geometric measures in Meshlab [9] reveals a shark that weighed ~51.96 metric tons/51,952 kg.
- 16 2D measurements previously estimated for an *O. megalodon* of this size were measured in Blender [7], with all falling within the predicted mean ± standard deviation ranges of that study [5].

Table 1: Possible model TL calculated from A2 teeth, based on previously published findings that are the best teeth for calculating TL [6].

<table>
<thead>
<tr>
<th>Label</th>
<th>3121.2.1.S.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tooth position</td>
<td>2nd right in 1st row; upper jaw</td>
</tr>
<tr>
<td>Tooth type</td>
<td>A2</td>
</tr>
<tr>
<td>CH (mm)</td>
<td>114.45</td>
</tr>
<tr>
<td>Equation (6)</td>
<td>12.103 (CH) + 2.160</td>
</tr>
<tr>
<td>TL (cm)</td>
<td>1387.35</td>
</tr>
</tbody>
</table>

Discussion

- The completed model being larger than the CH-TL calculation is due to the teeth not being associated with the vertebral column [3].
- The body is rather thin (close to minimum predicted values of dorsal-abdomen measurements from the 2D study); however this is likely because only a single GWS of ~3 m TL was used to reconstruct the body. The previous 2D study found that using multiple ecological & physiological analogues as a model to recreate *O. megalodon* produced a stockier reconstruction than using only the GWS [5].
- Body mass of ~52 metric tons is consistent with previous suggestions for a shark of this size [3].
- This study marks the first ever 3D computational model of an extinct giant shark; which can now be used to calculate a variety of inertial properties.

Acknowledgements

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References