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Original Article

Is minimally invasive approach to genioplasty predictable for mentolabial soft tissue? A retrospective cohort study

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A B S T R A C T

Introduction: The aim of this study was to conduct a three-dimensional analysis of the effects on mentolabial soft tissues of three different orthognathic surgery protocols: bimaxillary surgery without genioplasty, bimaxillary surgery with conventional or minimally invasive genioplasty (MIS).
Materials and methods: Pre-operative and post-operative CBCT were superimposed to quantify and ascertain the direction of mandibular movements, and soft tissue were analyzed to evaluate the hard to soft tissue ratio. Data from 97 consecutive patients were evaluated: 30 conventional genioplasty, 36 MIS and 31 no genioplasty.
Results: The impact of the surgical movements on the overlying soft tissues can be consider with stronger correlation in the group No Genioplasty in the whole mentolabial region, stronger correlation in labial and pogonion region in the MIS group and no stronger correlation in the conventional group.
Conclusions: Sutures in the mentolabial region directly interfere with the postoperative impact of orthognathic surgery on soft tissues in mentolabial area, in both the vertical and horizontal directions. A smaller incision – consequently involving less detachment of soft tissues in the region – may promote a lower risk of chin ptosis, in addition to greater suspension of the musculature.

1. Introduction

Bilateral sagittal split ramus osteotomy (BSSRO) is the most used intervention to correct cases of retrognathism and prognathism due to the greater diversity of surgical movements it allows, in addition to providing long-term stability. However, in some cases, it is important to understand and diagnose that chin deformities can exist independently of mandibular deformities. Thus, different surgical approaches to chin have been created and play a critical role in facial aesthetics [1,2].

Among the various techniques for aesthetic correction of the chin, horizontal osteotomy of the mandibular symphysis (genioplasty) is considered the most versatile procedure. The anterior bone structure of the mandible can be repositioned in several planes, allowing correction of sagittal, vertical and rotational deformities, with the soft tissues in the region following these bone movements and ultimately affecting the upper airways [3,4].

With the advent of contemporary orthognathic surgery, aesthetic factors have taken on a paramount role in the treatment of dentofacial deformities, unlike in previous times when orthognathic procedures were essentially functional [5]. If aesthetic goals should be achieved, the prediction of soft tissue changes is a key component of diagnosis and surgical planning for the mentolabial region [6,7].

The aim of this study was to conduct a three-dimensional analysis of the effects on mentolabial soft tissues of three different orthognathic surgery protocols: bimaxillary surgery without genioplasty, bimaxillary surgery with genioplasty performed using a conventional approach, and bimaxillary surgery with genioplasty performed by a minimally invasive surgery (MIS) approach.

2. Materials and methods

2.1. Sample selection

A longitudinal study was designed with patients who underwent orthognathic surgery between January 2016 and March 2022 at the Department of Oral and Maxillofacial Surgery at Hospital São Lucas of

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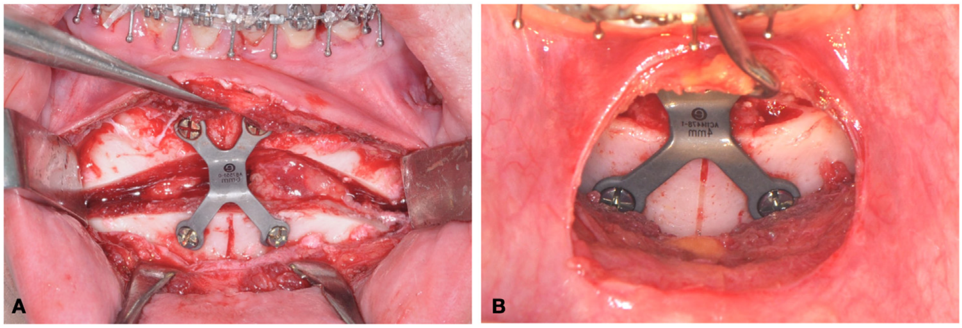

Fig. 1. Chin surgery - A) classic approach (G1); B) minimally invasive approach (G2).

Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, Brazil (Ethics committee approval - number 05/02890). All procedures were performed by the same two surgeons (OLHJ and RBO). Patients were divided into three groups according to surgical technique: Group 1, patients undergoing bimaxillary orthognathic surgery with conventional genioplasty; Group 2, patients undergoing bimaxillary orthognathic surgery with minimally invasive genioplasty; and Group 3, patients undergoing bimaxillary orthognathic surgery without genioplasty.

The inclusion criteria were: (1) dentofacial deformity requiring orthognathic surgery; (2) patients who were no longer growing and had non-syndromic deformities; (3) no history of facial trauma or previous surgery in the mentolabial region; (4) written informed consent; (5) patients with healthy, asymptomatic temporomandibular joints; and (6) CBCT scan at 1 week preoperatively (T0) and 6 months after surgery (T1). G1 patients underwent surgery between 2016 and 2018, while the patients of G2 underwent surgery between 2018 and 2022. The G3 patients were operated on over the 6 years of data collected.

Sample size was calculated and indicated that 30 participants were needed in each group to compare changes to the mentolabial region, based on an effect size of 0.25, statistical power of 80 %, and significance level of 5 %.

2.2. Surgical technique

All patients underwent bimaxillary orthognathic surgery under general anesthesia. In all procedures, bilateral sagittal ramus osteotomy was performed, via intraoral buccal incision between the retromolar and mesial regions of the mandibular second molar (without involving the facial mimic muscles), hybrid fixation and running stitches.

In Group 1 (G1), mandibular surgery was combined with a classic approach to the chin region (conventional genioplasty). A linear incision 30−40 mm long was made at the mucogingival junction from distal canine to distal canine, followed by detachment of facial mimic muscles (depressor labii inferioris, depressor anguli oris, and mentalis), exposure of the mental nerves bilaterally, horizontal osteotomy of the chin, and fixation with a chin plate and four monocortical screws. A layered closure was performed, first by placing a single stitch in each of the divided muscles, followed by running stitches for the mucosa (Fig. 1).

In Group 2 (G2), mandibular surgery was combined with a minimally invasive approach to the chin region. The genioplasty was performed through a V-shaped incision over the anterior region of the mandible, between lateral incisors (10−20 mm long), dividing only the mentalis muscles and detaching them completely to form a tunnel on each side that covers the region from the midline to the base of the mandible, through which horizontal osteotomy of the chin was performed followed by fixation with a chin plate and four monocortical screws [8,9]. A layered closure was performed, first closing the mentalis muscle on each side followed by running for the mucosa (Fig. 2).

In Group 3 (G3), bimaxillary surgery was performed without genioplasty, i.e., no damage to the soft tissues.

In the immediate postoperative period, patients received criotherapy for 72 h and compression taping. Standard antibiotic and anti-inflammatory therapy were prescribed.

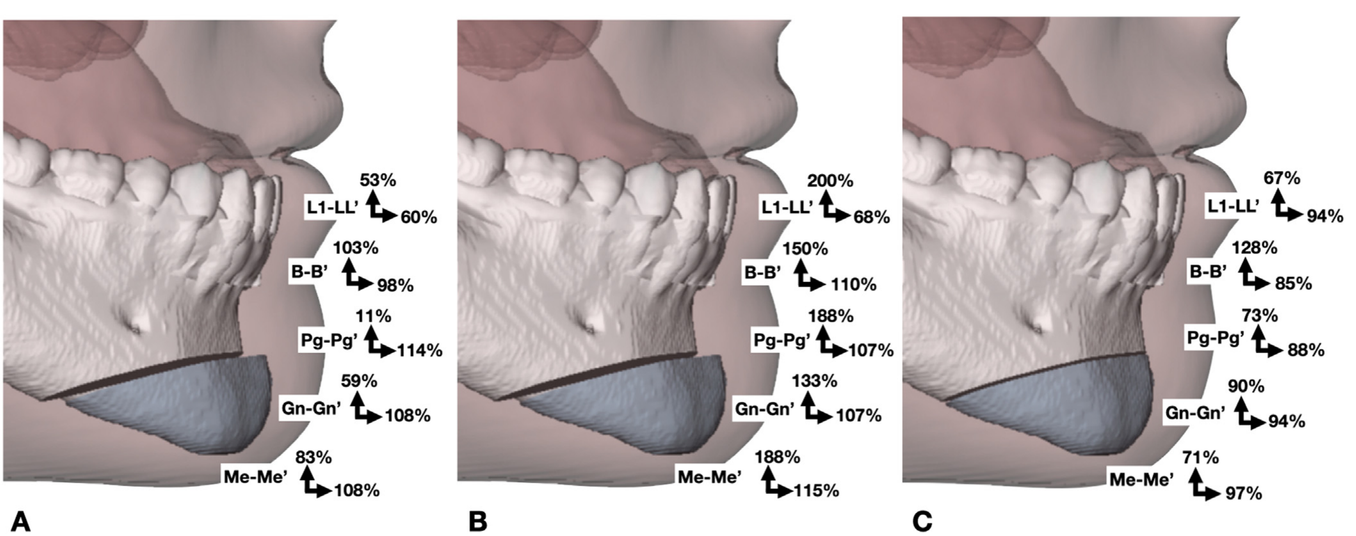

Fig. 2. Impact of surgical movements on soft tissues. A) Classic approach (G1); B) minimally invasive approach (G2); C) no chin surgery (G3).

2.3. Analysis of CT scans

Computed tomography images were obtained using iCAT Vision-Q software (version 1.8.0.5) and processed in Dolphin 3D Orthognathic Surgery Planning software (version 11.9). Voxel-based superimposition of preoperative (T0) and 4-to-6-month postoperative (T1) volumes were performed, using the anterior skull base.[10]

To quantify and ascertain the direction of mandibular movements, landmarks were drawn on the dental midline and mandibular bone; their corresponding soft tissue landmarkswere also considered: Incisal edge of lower incisor (L1), B point (B), Pogonion (Pg), Gnathion (Gn), Menton (Me), Labial inferior (Li'), B' point (B'), Pogonion' (Pg'), Gnathion' (Gn'), and Menton' (Me'). The mentolabial angle (Pg'-B'-Li') was also measured. To ensure accurate and reproducible measurements, the principal examiner (J.V.P.N.) repeated the protocol on virtual models of 10 patients 1 month after the first measurement. The same protocol was then repeated by a second examiner (O.L.H.J.), and the results compared by intraclass correlation coefficients (ICCs).

2.4. Statistical analysis

Data were evaluated in the Statistical Package for the Social Sciences (SPSS, version 20.0) for statistical analysis. As the Kolmogorov−Smirnov test rejected the assumption of normality, all variables were described as medians and interquartile ranges. Comparisons between groups were performed using the nonparametric Kruskal−Wallis test, followed by Dunn−Bonferroni post-hoc multiple comparisons. Spearman's correlation test was also performed for the different variables. The significance level was set at 5 %.

3. Results

Data from 97 consecutive patients were analyzed: 30 G1 (18 females, 12 males; median age 31.5 years, IQR 20−59 years), 36 G2 (26 females, 10 males; median age 31. 3 years, IQR 20−55 years); and 31 G3 (17 females, 14 males; median age 30.8 years, IQR 18−53 years).

Table 1 reports the surgical movements measured in hard tissues and soft tissues in the vertical and sagittal directions. Comparison among groups G1, G2, and G3 revealed a statistically significant difference (p = 0.035) in the vertical direction for the gnathion. This difference occurred between G1 and G2 (p = 0.022) and from these to G3 (p = 0.035). However, after adjusting for multiple comparisons by the Dunn−Bonferroni method, statistical significance was lost. For the menton region, there was a statistically significant difference (p = 0.038) and relationship between G2 and G3 (p = 0.043); after adjusting for multiple comparisons, the significance remained. Quantitatively, these differences were as follows: Me=1.2 mm and Gn=1.7 mm in G1 and Me=1.1 mm and Gn=1.5 mm in G2.

Regarding surgical movements in the sagittal direction, there were statistically significant differences (p = 0.043) for the soft tissue menton landmark. Such difference was found between G3 and G1

Table 1
Surgical movements measured in hard (tooth and bone) and soft tissues in the vertical and sagittal directions. (IIQ: interquartile range; P25: 25th percentile; P75: 75th percentile; ab different letters indicate statistically significant differences after adjustment for Dunn Bonferroni).

Delta	G1			G2			G3			
	n = 30			n = 36			n = 31			
		IIQ			IIQ			IIQ		
	Median	P25	P75	Median	P25	P75	Median	P25	P75	p
Transversal										
L1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,074
LL'	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,074
Point B	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,074
Point B'	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,074
Pogonium	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,074
Pogonium'	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,074
Gnatium	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,074
Gnatium'	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,074
Mental	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,074
Mental'	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,074
Sagittal										
L1	1,5	−0,7	5,0	0,3	−1,0	2,7	1,8	−0,1	4,6	0,245
LL'	0,8	−2,0	4,0	0,6	−1,3	2,0	1,2	−1,6	3,8	0,761
Point B	1,0	−3,7	6,4	0,2	−3,2	2,6	1,8	−1,4	3,6	0,562
Point B'	1,3	−2,6	4,7	0,3	−2,4	2,4	2,3	−1,0	3,6	0,145
Pogonium	1,9	−2,3	5,2	0,8	−4,0	2,0	1,5	−1,4	2,9	0,051
Pogonium'	0,2	−5,1	4,1	1,5	−4,0	1,7	1,1	−2,1	2,9	0,139
Gnatium	1,7	−2,8	4,1	1,5	−4,8	1,8	1,0	−1,0	2,4	**0,035**
Gnatium'	1,0	−5,1	4,1	1,7	−4,1	1,9	0,9	−0,4	3,4	0,241
Mental	1,2[ab]	−3,2	3,2	1,1[a]	−5,3	0,9	0,7[b]	−0,8	2,0	**0,038**
Mental'	1,0	−3,8	4,2	1,7	−4,4	2,5	0,5	−0,6	3,2	0,314
Vertical										
L1	3,5	−0,7	5,8	3,8	0,0	6,9	1,8	−2,3	6,1	0,419
LL'	2,1	−0,8	4,6	2,6	0,2	4,9	1,7	−1,6	6,4	0,654
Point B	4,2	−0,2	6,8	5,0	0,5	8,0	2,6	−3,6	7,3	0,333
Point B'	4,1	1,1	6,8	5,5	0,7	7,5	2,2	−2,8	7,7	0,193
Pogonium	5,6	0,8	10,6	5,3	1,4	11,2	3,4	−2,7	9,0	0,219
Pogonium'	6,4	0,7	10,4	5,7	2,5	9,4	3,0	−2,4	8,2	0,141
Gnatium	6,3	1,4	10,8	6,1	1,3	11,9	3,3	−3,2	8,9	0,177
Gnatium'	6,8	0,4	10,7	6,5	2,9	11,3	3,1	−2,1	8,4	0,073
Mental	5,9	1,3	11,0	6,5	1,4	11,8	3,3	−2,7	9,6	0,186
Mental'	6,4	0,6	11,4	7,5	2,5	12,2	3,2	−3,1	7,4	**0,043**

Table 2
Spearman correlation between soft-tissue and hard-tissue (LL: Lower lip; L1: Lower incisor; B': soft tissue point B; B: hard tissue point B; Pg': soft tissue Pogonium; Pg: hard tissue Pogonium; ** Strong correlation; * Statistical significant).

Spearmann Correlation (rs)	G1 n = 30 rs / p	G2 n = 36 rs / p	G3 n = 31 rs / p
Transversal			
LL'-L1	0.246 / 0.191	0.034 / 0.844	−**0.416**/ 0.020**
B'- B	0.246 / 0.191	0.034 / 0.844	−**0.416**/ 0.020**
Pg'- Pg	0.246 / 0.191	0.034 / 0.844	−**0.416**/ 0.020**
Sagittal			
LL'-L1	0.234 / 0.214	0.285 / 0.092	**0.475** / 0.007***
B'-B	−0.046 / 0.808	−0.136 / 0.431	0.135 / 0.470
Pg'-Pg	−0.052 / 0.786	−0.214 / 0.210	0.049 / 0.792
Vertical			
LL'-L1	−0.118 / 0.535	**0.465**/ 0.004***	**0.629**/ <0.001***
B'-B	0.057 / 0.765	**0.500**/ 0.002***	**0.739**/ <0.001***
Pg'-Pg	−0.124 / 0.513	0.147 / 0.392	**0.638**/ <0.001***

Table 3
Repercussion of bone surgical movements on soft tissues. Ratio soft-tissue to bone-tissue.

	G1 Sagittal	n = 30 Vertical	G2 Sagittal	n = 36 Vertical	G3 Sagittal	n = 31 Vertical
L1-LL'	60 %	53 %	68 %	200 %	94 %	67 %
B-B'	98 %	103 %	110 %	150 %	85 %	128 %
Pg-Pg'	114 %	11 %	107 %	188 %	88 %	73 %
Gn-Gn'	108 %	59 %	107 %	133 %	94 %	90 %
Me-Me'	108 %	83 %	115 %	188 %	97 %	71 %

(p = 0.045) and between G3 and G2 (p = 0.021). Again, however, after adjusting for multiple comparisons by the Dunn−Bonferroni method, this statistical significance was lost. There were no other significant differences in how the anatomic structures were changed by the three different techniques (Table 1).

The intraclass correlation coefficient was 0.978 within the same rater and 0.923 between different raters.

Analysis of Spearman correlations showed, in the vertical direction, a strong and significant ($p < 0.001$) correlation between hard tissues and soft tissues in all landmarks assessed, with the magnitude of correlation being greater in the following order: G3>G2>G1. For surgical movements in the vertical direction in Group 2, some correlations were significant, especially concerning the lower lip landmark and point B hard and soft tissue. Regarding transverse surgical movements in Group 3, significant differences ($p < 0.05$) are showed in all landmarks of interest (Table 2). Overall, there was an excellent correlation between bone structures and their respective soft tissue, with the most robust correlations found closer to the menton, gnathion, and pogonion reference points.

The impact of the surgical movements on the overlying soft tissues can be seen in Fig. 2, which shows the surgical movement percent in the vertical and sagittal directions (Table 3).The mean change in the mentolabial angle was −2.0°, 5.8°, and −0.9° in groups G1, G2, and G3, respectively (Table 4).

4. Discussion

Among the genioplasty techniques, horizontal chin osteotomy combined with an intraoral approach to the anterior mandible is the most common [10]. This technique aims to correct a diversity of chin deformities as retrusion, extrusion, enlargement, and narrowing, thus providing both functional and aesthetic benefits to patients [11]. In addition to the three-dimensional positioning of the chin for optimal aesthetics, the slope of the mandibular incisors must be considered to plan the sagittal movement of the chin and ensure a proper lip seal [4,12]. It is well known that surgical repositioning of the chin causes soft tissue changes in the surrounding region, which means surgeons must diagnose and plan how their intervention on bony structures will affect the overlying soft tissues [13].

The authors of this article conducted a study with the aim of obtaining the repercussions of different genioplasty techniques on the soft tissues of the mentolabial region, comparing the conventional technique with the minimally invasive one and having as a control group patients who did not receive genioplasty. Soft tissue prediction is not always straightforward, as some factors − such as age, surgical technique, and range of surgical movement − can directly influence outcomes. Analyzing the outcomes obtained with the different surgical techniques while reducing the risk of bias, the variables age and range of surgical movement were controlled in this study: all three groups had an average patient age of approximately 31 years, and in terms of range of the surgical movement, there was only one significant difference in the chin region between the groups which underwent genioplasty (G1 and G2) and that which did not (G3); furthermore, these differences of 0.5 mm and 0.4 mm is clinically irrelevant. There were no significant differences between G1(median of 6.3 mm in the sagittal plane and 1.7 mm in the vertical plane) and G2 (median of 6.1 mm in the sagittal plane and 1.5 mm in the vertical plane), which demonstrates a well-controlled sample in terms of the range of surgical movement; the small difference in relation to G3 is clearly explained by the lack of any surgical approach to the chin region.

By controlling the variables age and range of surgical movement, it was able to analyze the impact of the different surgical techniques. Considering the intervention groups, the incision was made between the buccolabial sulcus and the vermilion border of the lower lip, to avoid contractures [14,15]; however, the size of the incision and extent of mucoperiosteal detachment were different, so that in G1, the incision encompassed the mentalis, depressor labii inferioris, and depressor anguli oris muscles, while in G2, the incision encompassed only the mentalis muscle. The role of the facial mimic muscles is to elevate and depress the lower lip and chin, beyond that, mentalis muscle provides the greatest vertical support for the mentolabial region. If these muscles are divided and not reconstructed subsequently, chin ptosis and lower labial incompetence may ensue [5,9,16,17]. Considering that the trauma to the facial muscles is reduced by the smaller incision employed in the minimally invasive method, there is a significant reduction in the adverse effects of surgical trauma in the region when this technique is used. This becomes evident when analyzing our outcomes regarding vertical positioning of the lip. Suturing of the chin muscles had a greater effect in the minimally invasive group, with the impact of surgical movements on soft

Table 4
Mentolabial angle. *Degrees (⁰).

Delta	G1			G2			G3			
	n = 30			n = 36			n = 31			
		IIQ			IIQ			IIQ		
	Median	P25	P75	Median	P25	P75	Median	P25	P75	p
Mentolabial Angle	−2.0	−15.6	12.8	5.8	−5.5	13.2	−0.9	−15	14.6	0.318

tissues ranging from 133 % to 200 %, unlike with the conventional technique, in which impact ranged from 11 % to 103 %; this suggests a lower risk of muscle ptosis and excess exposure of the mandibular incisors with the minimally invasive approach. In addition, the use of increasingly smaller incisions and increasingly reduced detachment of the overlying muscles has shortened recovery and lowered morbidity, as well as improved facial movement in the postoperative period [7,10].

The tissue response was very similar between the conventional and minimally invasive groups in antero-posterior surgical movement. However, no-genioplasty group showed less soft tissue volume gain when compared to the other groups. Therefore, it is believed that muscle sutures and mucosal sutures have a major effect on soft tissue volumization, having an effect quite similar to that of the V-Y suture in the nasolabial region [9,18]. In the horizontal direction of surgical movement, the greatest difference between the minimally invasive group and the conventional group was at the soft tissue B point, precisely where the sutures placed in each technique are located, suggesting that techniques involving smaller incisions and little muscle detachment provide a superior tissue response [2,19].

When genioplasty was not performed, the soft tissues showed a greater correlation with the surgical movements performed on bony structures as compared to the groups in which genioplasty techniques were employed. This is explained by the lack of any detachment or even division of the involved muscles; therefore, the impact on the soft tissues was more faithful to that predicted. When comparing intervention groups, G2 was superior to G1, showing strong correlations between surgical bone movements and resulting impact on soft tissues, while in G1 there was no strong correlation. This information is also attributable to the smaller incision and reduced muscle detachment.

As for the mentolabial angle, a greater correlation was also observed for soft tissue changes in minimally invasive approach as compared to the conventional approach. Once again, this finding is related to less damage to the soft tissue [7,19]. It is thus increasingly evident that the most faithful soft tissue reproduction in orthognathic surgery is achieved through minimally invasive approaches, which provide greater postoperative predictability of patient outcomes [19,20,21].

5. Conclusion

Sutures in the mentolabial region directly interfere with the postoperative impact of orthognathic surgery on soft tissues in this area, in both the vertical and horizontal directions. A smaller incision − consequently involving less detachment of soft tissues in the region − may promote a lower risk of chin ptosis, in addition to greater suspension of the musculature.

Patient consent

Written patient consent was obtained to publish the surgical photographs.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

O.L. Haas: Validation, Supervision, Conceptualization. **J.V. Pessoa Neto:** Writing − original draft, Investigation. **A.P. Sousa Gil:** Writing − original draft, Investigation. **B. Mello da Rosa:** Writing − review & editing, Visualization. **R.M. Bastos:** Writing − review & editing, Methodology. **M. Giralt-Hernando:** Visualization. **A. Valls-Ontañón:** Writing − review & editing. **F. Hernández-Alfaro:** Writing − review & editing, Supervision, Conceptualization. **R.B. de Oliveira:** Writing − review & editing, Resources, Project administration.

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Supplementary materials

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