Arch Health Invest (2023)12(1):6-11
http://doi.org/10.21270/archi.v12i1.6049

Original Research

Digital Workflow in the Analysis of Orofacial Cleft in Children: Case Series with 5 Years of Follow-Up

Fluxo de Trabalho Digital na Análise de Fissura Orofacial em Crianças: Série de Casos com Acompanhamento de 5 Anos

Flujo de Trabajo Digital en el Análisis de la Fisura Orofacial en Niños: Serie de Casos con 5 Años de Seguimiento

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Abstract

An objective was detailed the digital workflow steps to analyze dental arch of children with cleft lip and palate. Five children underwent impressions of the upper dental arches in the following stages: Stage 1 – before lip repair (3 months of life); Stage 2 – after lip repair/ before palate repair (12 months of life); Stage 3 – after palate repair (24 months of life); and Stage 4 – with early complete/ mixed deciduous dentition (from 5 years of age). After the impressions, dental casts were made with orthodontic plaster, and trimmed to obtain standardized dentoalveolar bases. Dental cast digitalization was performed using a 3D scanner coupled to a computer. Using stereophotogrammetry system software, anatomical landmarks were delimited for the evaluation of linear measurements, palatal surface area, volume, and dental arch superimposition. It is concluded that, the digital analysis of dental arches represents a significant change in the diagnostic process and treatment planning of children with orofacial clefts. The multiplicity of equipment and software guarantees reliable, reproducible, and valid tools for use in clinical practice and in scientific research.

Descriptors: Cleft Lip; Cleft Palate; Child; Dental Arch; Imaging, Three-dimensional.

Resumo

Detalhar as etapas do fluxo de trabalho digital para análise do arco dentário de crianças com fissura labiopalatina. Cinco crianças foram submetidas a moldagens dos arcos dentários superiores nas seguintes etapas: Etapa 1 – antes do reparo labial (3 meses de vida); Etapa 2 – após a reparação labial/antes da reparação do palato (12 meses de vida); Etapa 3 – após reparação do palato (24 meses de vida); e Etapa 4 – com dentição decídua completa/mista precoce (a partir dos 5 anos de idade). Após as moldagens, modelos de gesso foram confeccionados com gesso ortodôntico e recortados para obtenção de bases dentoalveolares padronizadas. A digitalização dos modelos de gesso foi realizada por meio de um scanner 3D acoplado a um computador. Usando o software do sistema de estereofotogrametria, os pontos anatômicos foram delimitados para a avaliação de medidas lineares, área de superfície palatina, volume e sobreposição do arco dentário. Conclui-se que, a análise digital dos arcos dentários representam uma mudança significativa no processo diagnóstico e no planejamento do tratamento de crianças com fissuras orofaciais. A multiplicidade de equipamentos e softwares garante ferramentas confiáveis, reprodutíveis e válidas para uso na prática clínica e na pesquisa científica.

Descritores: Fenda Labial; Fissura Palatina; Criança; Arco Dental; Imageamento Tridimensional.

Resumen

Detallar los pasos del flujo de trabajo digital para el análisis de la arcada dentaria de niños con labio y paladar hendido. A cinco niños se les realizaron impresiones de las arcadas dentarias superiores en las siguientes etapas: Etapa 1 – antes de la reparación del labio (3 meses de edad); Etapa 2: después de la reparación del labio/antes de la reparación del paladar (12 meses de vida); Etapa 3: después de la reparación del paladar (24 meses de edad); y Etapa 4 – con dentición decidua completa/mixta temprana (a partir de los 5 años de edad). Después de las impresiones, se realizaron modelos de yeso con yeso de ortodoncia y se cortaron para obtener bases dentoalveolares estandarizadas. La digitalización de los modelos de yeso se realizó mediante un escáner 3D acoplado a una computadora. Utilizando el software del sistema de estereofotogrametría se delimitaron los puntos anatómicos para la evaluación de medidas lineales, superficie palatina, volumen y superposición de la arcada dentaria. Se concluye que el análisis digital de las arcadas dentarias representa un cambio significativo en el proceso de diagnóstico y planificación del tratamiento de los niños con fisuras orofaciales. La multiplicidad de equipos y software garantiza herramientas fiables, reproducibles y válidas para su uso en la práctica clínica y la investigación científica.

Descriptores: Labio Leporino; Fisura del Paladar; Niño; Arco Dental; Imagenología Tridimensional.

INTRODUCTION

Clinical documentation through impressions in early childhood, especially in individuals with cleft lip and palate, is considered the gold standard. Impressions enables analysis of dental arches from birth to skeletal maturity. Improves diagnosis, treatment plan, assessment of dental arches and longitudinal monitoring, contributes to individualization of rehabilitation protocols[1-4].

The three-dimensional (3D) technology allowed a significant change in data acquirement, moreover the modernization of anthropometric analysis. The 3D scanner is widely used to digitalization of dental arch, while paid or open-source software is used to evaluate the outcomes of palatal growth and development. The equipment and software performed this process of development evaluation in a precise, reliable, and fast way[5-8].

An objective of this study was detailed the digital workflow steps to analyze dental arch of children with cleft lip and palate.

CASE REPORTS

- *Routine of the Hospital*

The rehabilitation protocol of the Hospital for Rehabilitation of Craniofacial Anomalies/ University of São Paulo (HRAC/ USP), children with oral clefts underwent to ambulatorial appointments from 3 months up to 5 years old. Habitually, those areas are pediatric dentistry, speech therapy and plastic surgery undergoing outpatient clinical care before and after primary surgeries[9,10].

Children with cleft lip and/or palate perform lip repair at 3 months old, and they undergo to ambulatorial reassessment at 12 months old. Children with cleft lip and palate, and cleft palate perform palate repair at 12 months old, and they undergo to ambulatorial reassessment at 24 months old. After 5 years old, regardless of cleft phenotype, all children undergo to ambulatorial reassessment[9,10].

- *Case Reports*

The study was approved by the Research Ethics Committee (Reference number #2.481.667). Four children at 3 months old with different clefts type, unilateral complete cleft lip (UCL), bilateral complete cleft lip (BCL), unilateral cleft lip and palate (UCLP) and bilateral cleft lip and palate (BCLP), to beginning the rehabilitative process as lip repair. And one child at 12 months old with complete cleft palate (CP), to beginning the rehabilitative process as palate repair. All individuals were accompanied by guardians or parents. They presented good systemic health and absence of other anomalies according to medical examinations.

During all outpatient visits performed by pediatric dentists, a clinical examination was initially carried out, and oral hygiene guidelines were given to legal guardians. Before the impression of dental arch, the responsible were oriented and informed about the importance of impressions and how it was conducted.Children with cleft lip and palate underwent impressions of the upper dental arches in the following stages: Stage 1 (S1) – before lip repair (3 months of life); Stage 2 (S2) – after lip repair/ before palate repair (12 months of life); Stage 3 (S3) – after palate repair (24 months of life); and Stage 4 (S4) – with early complete/mixed deciduous dentition (from 5 years of age).

When the five children were aged 3 to 24 months (S1, S2, and S3), they were set on the adult's lap. The pediatric dentist positioned herself at 12 hours in relation to the child. During the impression, the dentist held the right hand in the child's mouth, while the finger-positioning of the opposite hand was indicated in the retromolar region to open the mouth. The manufactured tray was kept in position until the material was completely steady. Followed by the assessment of quality and anatomical reproduction of the palate of the impression. Palate impressions were performed using acrylic customized trays according to the type of orofacial cleft (Figure 1). When necessary, peripheral wax was applied for better adaptation of the molding and sealing of the reg ion of fornix[11].

Figure 1: Customized tray of acrylic resin for molding in children between 3 and 24 months of age.

The material of choice was condensation silicone (Perfil, Vigodent S/A Indústria e Comércio, Rio de Janeiro, RJ, Brazil), prepared according to the manufacturer. From the age of 5 years (S4), children were molded with an infant tray (Tecnodent, Indaiatuba, SP, Brazil) with irreversible hydrocolloid (Orthoprint, Zhermack SpA, Badia Polesine, RO, Italy). After the impressions, dental casts were made with orthodontic plaster (Pason, São Paulo, SP,

http://doi.org/10.21270/archi.v12i1.6049

Brazil), and trimmed to obtain standardized dentoalveolar bases, followed by finishing and polishing.

- *Digital Dentistry*

Dental cast digitalization was performed using a 3D scanner (3Shape's R700™ Scanner, Copenhagen, K, Denmark) coupled to a computer[6]. The system has 2 cameras with a resolution of 1.3 megapixels and 3 axes and an optical laser technology. Full arch sweep time is 3 minutes. Dental cast digitalized, as image, were exported from the Standard Tessellation Language, and filed in the institutional database. Using stereophotogrammetry system software (Mirror imaging software, Canfield Scientific Inc., Fairfield, NJ, USA), anatomical landmarks were manually delimited for the evaluation of linear measurements, palatal surface area, volume, and dental arch superimposition.

Linear measurements were performed using landmarks points that are joined to form measurement lines according to their Cartesian planes, resulting in distance between points expressed in mm (Table 1, Figure 2) [12-15].

Table 1 – Description of linear measurements.

Linear measurement	Definition
C - C'	Intercanine distance – transverse line between between the cusps of the deciduous Canines in the right (C) and the left (C') segments.
T - T'	Intertuberosity distance – transverse line between the Tuberosities in the right (T) and the left (T') segments.
I-CC'	Anterior lenght of the palate – sagittal line from point Intercisive (I) perpendicular to the C - C' distance.
I-TT'	Total lenght of the palate – sagittal line from point I perpendicular to the T - T' distance.

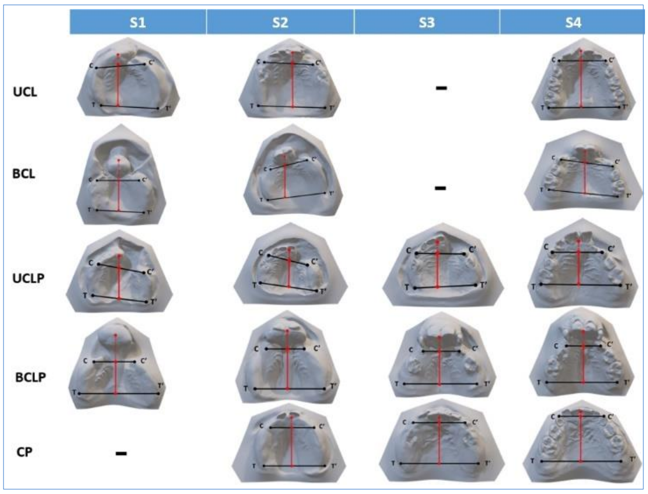

Figure 2: Linear measurements at S1, S2, S3 and S4.

The delimitation of the palatal surface area (except the cleft) was performed using 30 equidistant landmarks, contouring dental arch by the crest of the alveolar ridge (clockwise) and with a posterior limit at the T-T` distance. The area was quantified in mm² (Figure 3)[14].

The delimitation of the dental arches for volumetric analysis was performed using 30 equidistant landmarks positioned between the fornix and alveolar ridge. After delimitation, the demarcated region of dentoalveolar base was separated from rest of dental arch, for further calculation. The approximate volume of the palatal segments in cm³ (Figure 4)[3,7,14].

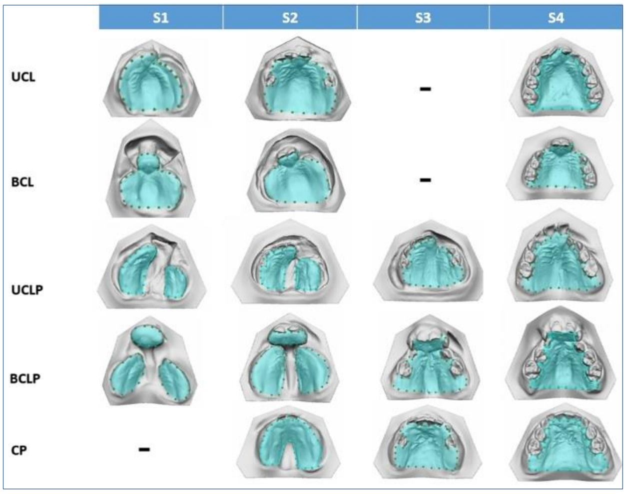

Figure 3: Palatal surface area at S1, S2, S3 and S4.

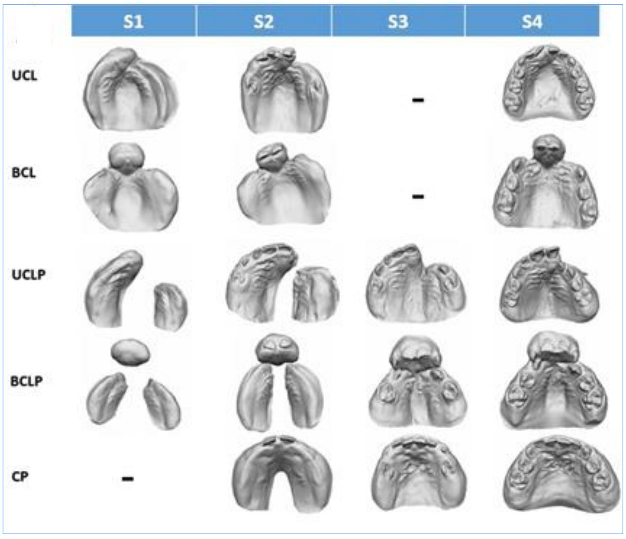

Figure 4: Volume of dental arches at S1, S2, S3 and S4.

The superimposition was performed by delimiting the palatal bone segments according to the same criteria defined in the volumetric analysis. Children with UCL, BCL, UCLP and BCLP underwent cheiloplasty. Thus, in these individuals, the dental arches from S2 were superimposed on S1 (Figure 5)[16].

Parallel, children with UCLP, BLCP and CP had post-palatoplasty dental casts (S3), superimposed on pre-palatoplasty (S2). The superimposition allows a quantitative analysis of the development by means of Root Mean Square (RMS), which value represents distances between the overlapping surfaces. The value was presented in mm. In addition, qualitative analysis was performed by chromatic map, in which regions of yellow/red and blue are anatomical points with greater discrepancies between the superimposed surfaces. Green regions shown areas where there was little or no significant change (Figure 5)[16].

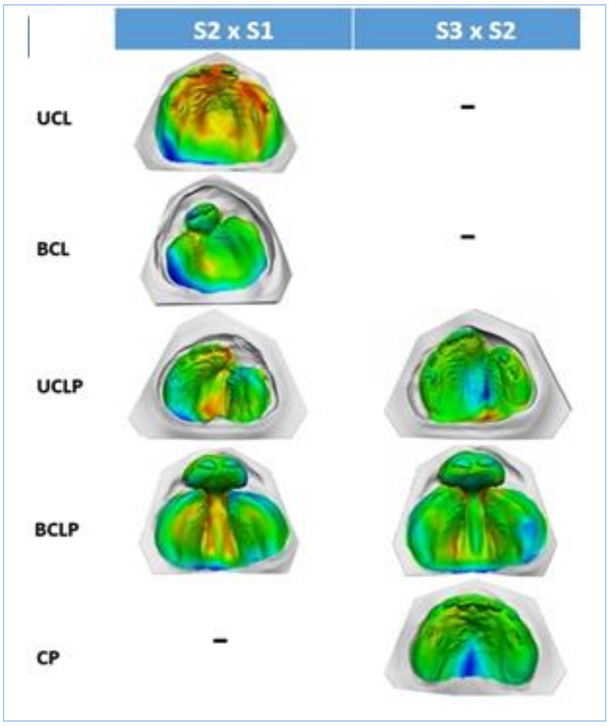

Figure 5: Post/preoperative dental arch superimposition.

DISCUSSION

The rehabilitative protocol of the institution states that the cheiloplasty should be performed at 3 months of life, palatoplasty at 12 months of life, and post-surgical following-up appointment at one year after the last plastic surgery[9]. Plaster dental casts take a large storage room in the institution with more than 110 thousand of individuals enrolled. Plaster is fragile, susceptible to fractures, loss, and degradation[8]. Thus, this study includes digitized dental models, which have the advantages of sharing information between institution, enabling the comparison of the outcomes of the rehabilitative treatment, not requiring further space, and no risk of fractures[5,8]. However, the information needs to be stored in cloud computing to avoid operational problems of loss or damage to hard disks or malfunctioning of computers and database. 3D digital models will enable the easy and fast access to the individual's information on electronic files.

The software to be used in this study shows accuracy, assuring the validation of the anthropometric analysis[5,7,8]. The use of linear measurements through landmarks has been largely used to quantify the development of 3D images of dental arches[8,12-15,17]. The analysis of the area of the palatal bone segments aims to evaluate the intrinsic tissue deficiency and to monitor the post-surgical growth of the cleft itself after lip repair[1,4,14,17,18].

The measurement of the volume may identify the amount of bone tissue between periods, without exposing the child to ionizing radiation of a computed tomography, for example[7,19]. The analysis of the volume enables the comprehensive view of the palate morphology by quantifying the intrinsic bone tissue deficiency of each cleft type and correlating with some variables, such as surgical technique and time[3]. The superimposition of 3D images of dental arches will indicate possible growth and development areas after surgery. It is worth highlighting that the superimposition provides the link between the theoretical knowledge on palate development and the clinical practice[14,16]. This method will enable that the professional understands better the effects of the rehabilitative treatment and the growth and development changes in palatal bone segments, through a global view of the palatal development.

Generally, anthropometry indicates the post-surgical evolution through the comparison among periods[1,3,4,12,20,21]. This will allow observing whether any step of the rehabilitative protocol requires attention and modification to assure proper maxillary development, considering that all children is treated at the same period[9]. Thus, specific rehabilitative protocols could be tailored for each cleft type, width, maxillary hypoplasia, amount of soft tissue, and genetic patterns.

- *Clinical Significance*

Among the most important clinical aspects of the application of digital dentistry in pediatric dental care for children with orofacial clefts, there is an improvement in diagnosis and operative planning, safer and faster clinical procedures and less invasive rehabilitation surgeries.

CONCLUSION

It is concluded that, although plaster models are the gold standard in clinical routine, digital analysis of dental arches represents a significant change in the diagnostic process and treatment plan of children with orofacial clefts. The multiplicity of equipment and software guarantees reliable, reproducible, and valid tools for use in clinical practice and in scientific research.

ACKNOWLEDGMENT

This study supported by São Paulo

Research Foundation (FAPESP; grant #2020/16690-0; and grant #2021/12424-6).

REFERENCES

1. Carrara CFC, Ambrosio ECP, Mello BZF, Jorge PK, Soares S, Machado MAAM, et al. Three-dimensional evaluation of surgical techniques in neonates with orofacial cleft. Ann Maxillofac Surg. 2016;6(2):246-50.
2. Kongprasert T, Winaikosol K, Pisek A, Manosudprasit A, Manosudprasit A, Wangsrimongkol B,et al. Evaluation of the Effects of Cheiloplasty on Maxillary Arch in UCLP Infants Using Three-Dimensional Digital Models. Cleft Palate Craniofac J. 2019;56(8): 1013-19.
3. Ambrosio ECP, Fusco NDS, Carrara CFC, Bergamo MT, Lourenço Neto N, Cruvinel T, et al. Digital Volumetric Monitoring of Palate Growth in Children With Cleft Lip and Palate. J Craniofac Surg. 2022;33(2):e143-5.
4. Jorge PK, Gnoinski W, Laskos KV, Carrara CFC, Garib DG, Ozawa TO, et al. Comparison of two treatment protocols in children with unilateral complete cleft lip and palate: Tridimensional evaluation of the maxillary dental arch. J Craniomaxillofac Surg. 2016; 44(9):1117-22.
5. De Menezes M, Cerón-Zapata AM, López-Palacio AM, Mapelli A, Pisoni L, Sforza C. Evaluation of a Three-Dimensional Stereophotogrammetric Method to Identify and Measure the Palatal Surface Area in Children with Unilateral Cleft Lip and Palate. Cleft Palate Craniofac J. 2016;53(1):16-21.
6. Barreto MS, Faber J, Vogel CJ, Araujo TM. Reliability of digital orthodontic setups. Angle Orthod. 2016;86(2):255-59.
7. Pucciarelli V, Pisoni L, De Menezes M, Ceron-Zapata AM, Lopez-Palacio AM, Codari M, et al. Palatal Volume Changes in Unilateral Cleft Lip and Palate Paediatric Patients, 6th International Conference on 3D Body Scanning Technologies. Lugano, Switzerland: 2015.
8. Sforza C, De Menezes M, Bresciani EB, Cerón-Zapata AM, López-Palacio AM, Rodriguez-Ardila MJ, Berrio-Gutiérrez LM. Evaluation of a 3D Stereophotogrammetric Technique to measure the Stone Casts of Patients with Unilateral Cleft Lip and Palate. Cleft Palate Craniofac J. 2012; 49(4):477–83.
9. Freitas JA, das Neves LT, de Almeida AL, Garib DG, Trindade-Suedam IK, Yaedú RY, et al. Rehabilitative treatment of cleft lip and palate: experience of the Hospital for Rehabilitation of Craniofacial Anomalies/USP (HRAC/USP) - Part 1: overall aspects. J Appl Oral Sci. 2012;20(1):9-15.
10. Freitas JA, Garib DG, Oliveira M, Lauris Rde C, Almeida AL, Neves LT, et al. Rehabilitative treatment of cleft lip and palate: experience of the Hospital for Rehabilitation of Craniofacial Anomalies-USP (HRAC-USP)-Part 2: Pediatric Dentistry and Orthodontics. J Appl Oral Sci. 2012;20(2):268–81.
11. Carrara CFC, Jorge PK, Costa B, Machado MAAM, Oliveira TM, da Silva Dalben G. Customized Tray for Impression Taking in Children with Cleft Lip and Palate. Cleft Palate Craniofac J. 2022:10556656221095713.
12. Ambrosio ECP, Sforza C, Menezes M, Gibelli D, Codari M, Carrara CFC, et al. Longitudinal morphometric analysis of dental arch of children with cleft lip and palate: 3D stereophotogrammetry study. Oral Surg Oral Med Oral Pathol Oral Radiol.2018;126(6):463-8.
13. Mello BZF, Ambrosio ECP, Jorge PK, de Menezes M, Carrara CFC, Soares S, et al. Analysis of dental arch in children with oral cleft before and after the primary surgeries. J Craniofac Surg. 2019;30(8):2456-58.
14. Ambrosio ECP, Sforza C, de Menezes M, Carrara CFC, Soares S, Machado MAAM, et al. Prospective cohort 3D study of dental arches in children with bilateral orofacial cleft: Assessment of volume and superimposition. Int J Paediatr Dent 2021;31(5):606-12.
15. Falzoni MMM, Ambrosio ECP, Jorge PK, Sforza C, de Menezes M, de Carvalho Carrara CF, et al. 3D morphometric evaluation of the dental arches in children with cleft lip and palate submitted to different surgical techniques. Clin Oral Investig. 2022;26(2):1975-83.
16. Ambrosio ECP, Sforza C, Carrara CFC, Machado MAAM, Oliveira TM. Innovative method to assess maxillary arch morphology in oral cleft: 3D-3D superimposition technique. Braz Dent J. 2021;32(2):37-44.
17. Ambrosio ECP, Sforza C, De Menezes M, Carrara CFC, Machado MAAM, Oliveira TM. Post-surgical effects on the maxillary segments of children with oral clefts: New three-dimensional anthropometric analysis. J Craniomaxillofac Surg. 2018;46(9):1511-14.
18. Prado DZA, Ambrosio ECP, Jorge PK, Sforza C, De Menezes M, Soares S, et al. Evaluation of cheiloplasty and palatoplasty on palate surface area in children with oral clefts: longitudinal study. Br J Oral Maxillofac Surg. 2022;60(4):437-42.
19. Generali C, Primozic J, Richmond S, Bizzarro M, Flores-Mir C, Ovsenik M, et al. Three-dimensional evaluation of the maxillary arch and palate in unilateral cleft lip and palate subjects using digital dental casts. Eur J Orthod. 2017;39(6):641-45.

20. Jaklová LK, Hoffmannová E, Dupej J, Borský J, Jurovčík M, Černý M, et al. Palatal growth changes in newborns with unilateral and bilateral cleft lip and palate from birth until 12 months after early neonatal cheiloplasty using morphometric assessment. Clin Oral Investig. 2021;25(6):3809-21.
21. Jaklová LK, Borský J, Jurovčík M, Hoffmannová E, Černý M, Dupej J, et al. Three-dimensional development of the palate in bilateral orofacial cleft newborns 1 year after early neonatal cheiloplasty: classic and geometric morphometric evaluation. J Craniomaxillofac Surg. 2020;48(4):383-90.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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Received 12/01/2023
Accepted 22/01/2023