Comparison of facial features in fetuses and newborns following natural delivery with cephalic presentation: a pilot study

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Abstract

Introduction Malocclusions are usually diagnosed around 3-4 years of age according to specific criteria. The purpose of this protocol is to validate a method to understand how the type of delivery can influence the development of malocclusions.

Materials and Methods This pilot study, conducted at the Fondazione IRCCS Cà Granda Ospedale Maggiore Policlinico of Milan, evaluated the relationship between the type of delivery, fetal presentation, and the presence of malocclusions in children. The sample included 5 healthy term newborns, all born to healthy mothers with uncomplicated pregnancies by vaginal delivery. Measurements were taken, via ultrasound, at the 37th week of gestation (T0) and on the second day of life (T1), using a craniometer, caliper and goniometer, including head circumference, lower facial angle, frontonasal angle, labial fissure length, and interpupillary distance.

Results The collected data show significant variations in some measurements between T0 and T1. Statistical analysis, conducted using the Wilcoxon Signed-Rank Test, indicated marginally significant differences for some measurements like the lower facial angle that showed a mean variation of -0.4°, while the interpupillary distance increased by 2.3 cm. However, no definitive correlation was found between the type of delivery and the presence of facial asymmetries.

Discussion and Conclusions The results suggest that further research is necessary to better understand the influence of delivery and fetal presentation on the development of malocclusions. This study represents an important first step, highlighting the need for larger samples and more in-depth investigation methods to obtain more conclusive results.

KEYWORDS Malocclusions, type of delivery, fetal presentation.

Introduction

Skeletal malocclusion is defined as an altered relationship between the maxilla and mandible or the presence of altered teeth alignment beyond the range of normality [Jacobson, 1987]. Malocclusion is considered the third priority for oral health disease according to the World Health Organization [Singh and Sharma, 2014]. Among the general population, its incidence, described in the literature, is between 50% to 87% [Cattaneo et al., 2005, Romasco et al., 2022]. Generally, the lack of knowledge about the aetiologic factors among them the intrinsic ones significantly reduces the likelihood of a favorable prognosis. Therefore, assessing the extent of etiological agents is the key factor in evaluating the stability of the outcome [Farronato et al., 2024; Maggiordomo et al., 2022]. To understand the aetiology of a dysgnathic condition, it is essential to determine whether the problem is caused by genetics or by the presence of altered functions, or more commonly, by a combination of both factors [Cenzato et al., 2024; Paglia, 2016; Tortora et al., 2023]. An almost entirely unexplored research area concerns the hypothesis that the type of delivery and fetal presentation can influence the development of malocclusions in childhood and adulthood. The impact of pressure on maxillofacial structures could cause significant damage to rapidly growing areas [Cenzato et al., 2023; Farronato et al., 2023; Colombo et al., 2023].

In the realm of prenatal diagnosis, until recently, the diagnosis of micrognathia and retrognathia was subjective, based on the assessment of the fetal profile and the analysis of the relationship between the maxilla and the mandible. [Storari et al., 2021] Today, however, retrognathia and micrognathia are conditions that can be evaluated separately. The use of objective ultrasound methods, such as measuring the lower facial angle and the mandibular width/maxillary width ratio, can facilitate the ultrasound recognition and characterisation of retrognathic and micrognathic fetal mandibles in utero [Antonakopoulos et al., 2019; Rotten et al., 2002; Maspero et al., 2020]. After birth, the diagnosis of malocclusion is made around the ages of 3-4 years according to specific criteria. Medical history, combined with a clinical examination and the processing of diagnostic data collected through instrumental investigations (cephalometric X-rays and 3D CT scans, cast analysis, photographic examinations, etc.), forms the basis for a correct diagnosis, which will be followed by the most appropriate treatment plan [Farronato et al., 2012; Maspero et al., 2009; Lombardo et al., 2020; Cenzato et al., 2024].

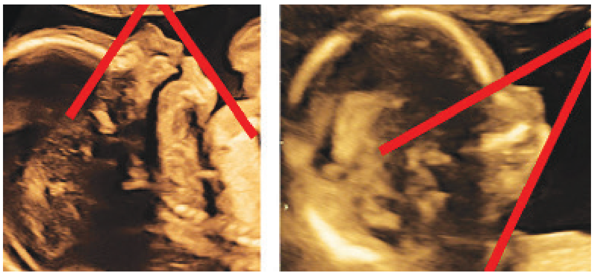


FIG. 1Lower facial angle (IFA) [Antonakopoulos N 2019]

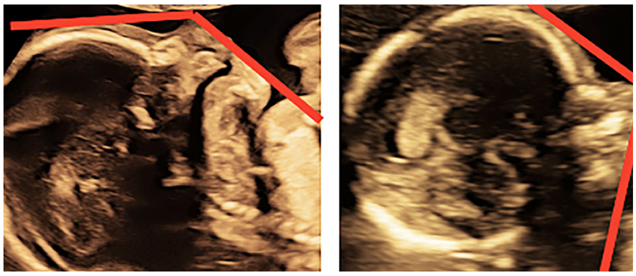


FIG. 2 Frontonasal-mentum angle (FNMA).) [Antonakopoulos N 2019]

To date, no studies have been published in the literature to understand whether the type of delivery and the type of fetal presentation play an actual role in the onset of malocclusions. Through a rigorous analysis of the collected data, this pilot study aims to provide a better understanding of the potential causes of dysgnathia and to contribute to the creation of more effective guidelines for the prevention and management of these conditions.

Materials and methods

This pilot study was conducted at the Fondazione IRCCS Cà Granda Ospedale Maggiore Policlinico of Milan in the departments of obstetrics, neonatology, and dentistry, with the aim of evaluating a possible relationship between the type of delivery, fetal presentation, and the potential presence of malocclusions in the infant. This study was approved as Research protocol of Fondazione IRCCS Cà Granda, Ospedale Maggiore Policlinico, Current Research, Operative Unit 420/425, Progressive number project 3.

Sample Selection

In the obstetrics department, a sample of five fetuses was selected. The research focused on fetuses without systemic diseases or diagnosable anomalies, in mothers who were not taking medications during pregnancy.

Inclusion and Exclusion Criteria

Inclusion criteria involved fetuses with cephalic, breech, or shoulder presentation, born through natural eutocic delivery, whether spontaneous or induced. Conversely, cases of twin pregnancies, births by cesarean section, or situations of dystocia during delivery were excluded.

Description of Measurements

For each subject, various data were collected at two distinct times: T0 (37th week of intrauterine life) and T1 (2nd day of life). These are standard and validated measurements typically used in the second trimester of intrauterine life for the ultrasound recognition of retrognathic mandibles and fetal retrognathia. These include:

Head Circumference (HC): Measured by placing the instrument at the most prominent point of the frontal bone above the supraorbital ridge and at the most prominent point of the occipital bone (opisthocranium). [Maspero et al., 2020].

Inferior Facial Angle (IFA): Measured in the median sagittal view of the fetus. It is formed by the intersection of a line orthogonal to the vertical part of the forehead drawn at the level of the nasofrontal suture and a line passing through the tip of the chin and the most prominent lip, usually the upper lip [Antonakopoulos et al., 2019].

Frontonasal-Mentum Angle (FNMA): Also measured in the sagittal view of the fetus's profile. It is the angle between the line drawn from the tip of the nose to the frontal bone, intersecting with the line from the nasal tip to the chin [Antonakopoulos et al. 2019; Hand et al., 2020].

Labial Fissure Length (LL): Measured in the coronal view of the fetus. It is obtained by drawing a line that connects the right and left labial commissures of the subject. The external points of the lips where they join at the corners of the mouth are identified, and the distance between them is measured [Lanteri et al., 2020; Colombo et al., 2019].

Interpupillary Distance (IPD): Also measured in the coronal view of the fetus. It is obtained by drawing a line that connects the centre of the pupil of the right eye with that of the left eye of the subject [Cenzato et al., 2021].

The presence of asymmetries was determined by evaluating the parallelism between the line indicating the labial fissure length (LL) and that of the interpupillary distance (IPD).

Data Collection Methodology

The same measurements were obtained at two distinct times: T0, during the 37th week of gestation via ultrasound, and T1, on the 2nd day of life. The data collection at T0 was conducted using the Samsung Ele v8® echography model. The measurements taken adhered to standard and validated clinical practices. At T1, an orthodontic specialist collected the data using a professional craniometer, caliper, and goniometer. This assessment was performed with the baby lying in a hospital crib in a supine position, with closed lips and open eyes. The data were then recorded in two separate tables: one containing information about the ethnicity and age of the mother, the type of conception, fetal presentation at T0, type of delivery, and the sex of the newborn (Table 1), and the other recording the various measurements taken from the study participants (Table 2). The primary objective of the study was to evaluate whether the mode of delivery and fetal presentation could influence the development of dysgnathia and asymmetries. To this end, measurements and angles detected in the fetus and subsequently in the newborn were compared, also examining the potential impact of the delivery mode and fetal presentation on the parallelism between LL and IPD.

Statistical Analysis

A descriptive and inferential statistical analysis was conducted on the collected data. The mean, standard deviation (SD), and 95% confidence interval (CI) were calculated for both T0 and T1, along with the p-value and Cohen's d. Additionally, for each measurement, the mean variation between the data collected at T0 and T1 (ΔT0-T1) was calculated, and the Wilcoxon Signed-Rank Test, a non-

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Pregnant ethnicity	Caucasian	Caucasian	Slavic	Arab	Caucasian
Pregnant age	40 y	32 y	35 y	25 y	38 y
Fertilization	Natural	Natural	Natural	Natural	Natural
Fetal presentation (T0)	Cephalic	Cephalic	Cephalic	Cephalic	Cephalic
Type of birth	Natural eutocic,not induced	Natural eutocic,not induced	Natural eutocic,not induced	Natural eutocic, induced	Natural eutocic,not induced
Newborn sex	F	M	F	F	M

TABLE 1 Ethnicity of the pregnant woman, age of the pregnant woman, type of fertilization, fetal presentation at T0, type of delivery, and sex of the newborn.

parametric test comparing paired measurements, was conducted to determine if there is a significant difference between T0 and T1. The results were then reported in a table (Table 3).

Results

The results are illustrated in tables 1, 2, and 3. The sample of pregnant women consisted of five individuals, three of whom were Caucasian, one of Arab ethnicity, and one of Slavic ethnicity. The average age of the patients was 34 years, and in all five cases, the conception of the newborn occurred through natural fertilisation. As reported in Table 1, four of the mothers involved in the study gave birth via non-induced natural eutocic delivery, while only one had an induced natural eutocic delivery. All examined newborns presented in a cephalic position. Additionally, three newborns were female, and two were male. Table 2 reports the measurements taken at times T0 and T1. The mean, standard deviation (SD), and the 95% confidence interval (CI) for each measurement at T0 and T1 were calculated. The upper and lower CIs provide the range within which the true mean is expected to fall with 95% confidence. Finally, the average variation between T0 and T1 (ΔT0-T1) was also calculated.

	Patient 1		Patient 2		Patient 3		Patient 4		Patient 5	
Sagittal view	T0	T1	T0	T1	T0	T1	T0	T1	T0	T1
Inferior facial angle (IFA)	61°	57°	65°	58°	60°	67°	56°	52°	48°	54°
Frontonasal-Mentum angle	129°	137°	128°	144°	142°	139°	131°	136°	144°	139°
Frontal view										
Interpupillary distance (IPD)	4,2 cm	5 cm	3,6 cm	5 cm	3,7 cm	9 cm	3,3 cm	6 cm	3,7 cm	5 cm
Labial Fissure Length (LL)	2,2 cm	3 cm	2 cm	3 cm	3 cm	5 cm	2,7 cm	4 cm	2,8 cm	5 cm
Other										
Parallelism	Sì	Sì	Sì	No	Sì	Sì	Sì	No	No	No
Head Circumference (HC)	32,8 cm	34 cm	31,3 cm	33,5 cm	32,5 cm	34,5 cm	31,6 cm	33,8 cm	32,5 cm	34,7 cm

TABLE 2 Measurements at Time T0 and T1 of: lower facial angle (IFA), fronto-nasal-mandibular angle (FNMA), interpupillary distance (IPD), distance between lip commissures (LL), parallelism, and cranial circumference (HC).

Regarding the inferior facial angle (IFA), at T0, the mean was 58° ± 6.4 (SD), and the 95% confidence interval (CI) for this measurement ranged from 50.0° to 66.0°. At T1, the mean was 57.6° ± 5.8 (SD), with a 95% confidence interval (CI) ranging from 50.4° to 66.0°. Overall, the average variation between T0 and T1 (ΔT0-T1) was -0.4°. For the frontonasal-mentum angle (FNMA), the mean at T0 was 134.8° ± 7.6 (SD), and the 95% confidence interval ranged from 124.4° to 144.2°. At T1, the mean was 139° ± 3.1 (SD), with a 95% confidence interval ranging from 135.2° to 142.8°. The average variation (ΔT0-T1) was +4.2°.

For interpupillary distance (IPD), the mean at T0 was 3.7 cm ± 0.3 (SD), with a 95% confidence interval ranging from 3.3 cm to 4.1 cm. At T1, the mean was 6 cm ± 1.7 (SD), with a 95% confidence interval ranging from 3.8 cm to 8.2 cm. The average variation between T0 and T1 was +2.3 cm.

For the labial fissure length (LL), the mean at T0 was 2.5 cm ± 0.4 (SD), with a 95% confidence interval ranging from 2.0 cm to 3.1 cm. At T1, the mean was 4 cm ± 1.0 (SD), with a 95% confidence interval ranging from 2.8 cm to 5.2 cm. The calculated average variation (ΔT0-T1) was +1.5 cm. Regarding head circumference (HC), the mean at T0 was 32.1 cm ± 0.7 (SD), with a 95% confidence interval ranging from 31.3 cm to 32.9 cm. At T1, the mean was 34.1 cm ± 0.5 (SD), with a 95% confidence interval ranging from 33.5 cm to 34.7 cm. The average variation in head circumference between T0 and T1 was 1.96 cm.

Distinguishing between male and female subjects, the average head circumference at T0 was 32.3 cm ± 0.50 (SD) for females and 31.9 cm ± 0.6 (SD) for males, while the average HC at birth was 34.1 cm ± 0.29 (SD) for females and 34.1 cm ± 0.6 (SD) for males.

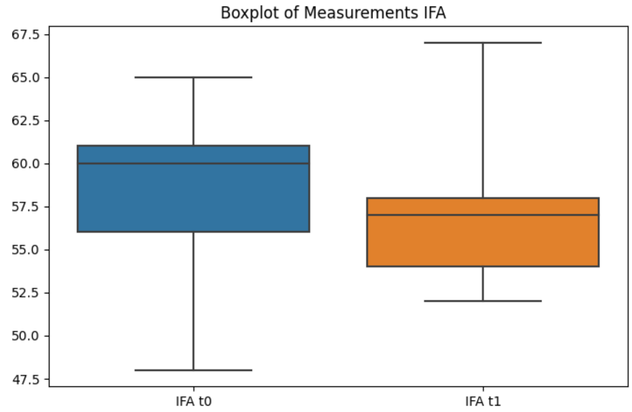
Finally, parallelism between the line used to measure labial fissure length (LL) and that of the interpupillary distance (IPD) was found in only two cases at both T0 and T1. Symmetry was observed in two cases at T0 but not at T1, while one patient was asymmetrical at both T0 and T1.

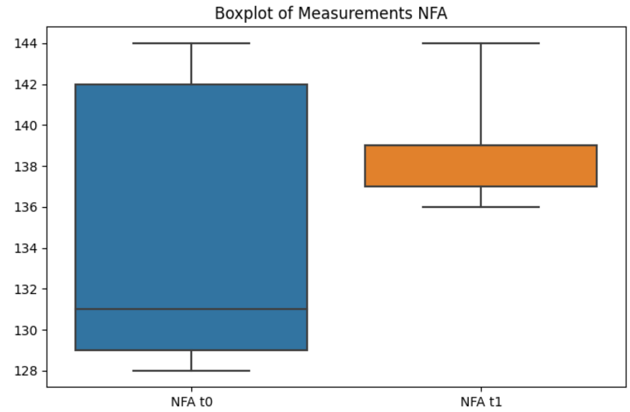
Subsequently, visualisations were created using boxplots to illustrate the data distribution and changes over time.

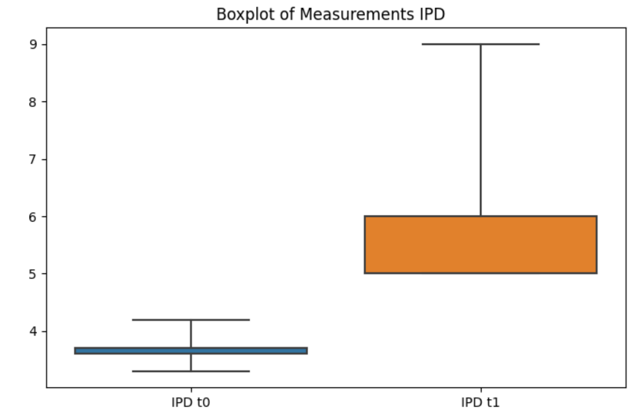
Lastly, for each measurement, a group comparison between T0 and T1 was conducted to evaluate the difference between the time points. The Wilcoxon Signed-Rank Test, a non-parametric test, compared paired measurements to determine if there was a significant difference between T0 and T1. The average difference between T0 and T1 was calculated and reported with 95% confidence intervals. The results are presented in Table 3.

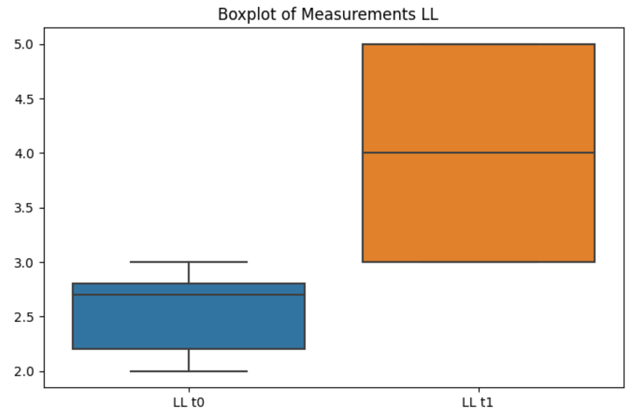
Discussion

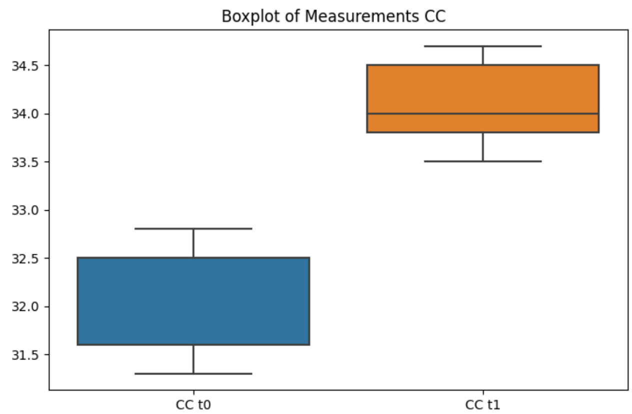
Upon analysing the statistical survey data, it is evident that the Wilcoxon Signed-Rank Test results for measurements IFA and FNMA indicate no significant differences. For IPD, LL, and CC measurements, the Wilcoxon test statistics yielded a p-value of 0.0625, suggesting marginally significant differences at the 10% level. The effect size was calculated to determine the magnitude of the difference between T0 and T1, crucial for estimating sample sizes in future studies for statistical significance. Cohen's d characterises effect size by relating











the mean difference to variability, akin to a signal-to-noise ratio. A high Cohen's d indicates that the mean difference is large compared to variability. Currently, there are no scientific publications thoroughly examining the potential correlation between delivery mode, fetal presentation, and the onset of malocclusions. However, comparisons were made with analogous studies found in the literature. This underscores the urgency for further targeted research to fill this gap in scientific knowledge and gain a more comprehensive understanding of the topic at hand.

Regarding the Inferior Facial Angle (IFA), the study by Antonakopoulos et al. [2009] recognises its relevance in the initial diagnosis of fetal micrognathia, commonly performed during routine anatomical scanning in the second trimester of pregnancy. The average gestational age for diagnosis, according to literature, is 21 weeks, ranging from 16 to 38 weeks. The reported normal average value is 65° ± 16°, with upper and lower reference limits ranging from 81° to 49°. Thus, an angle below 49° diagnoses micrognathia, with a sensitivity and specificity of 100% and 99%, respectively. Additionally, a systematic review by Cang et al. [2023] recommends using IFA <50° as a diagnostic criterion for micrognathia during prenatal examination. Analysing our study results, both at T0 and T1, the average IFA measurement exceeded 49°, indicating no micrognathia diagnosis in any of the studied cases. Furthermore, the overall mean change in IFA between T0 and T1 (ΔT0-T1) was -0.4°. Generally, the data decreased after birth in three infants, while increasing in the other two cases. For the Frontonasal-Mental Angle (FNMA), according to Antonakopoulos' study [2009], the normal average value is 147° ± 2.7° (SD), with upper and lower reference limits between 142° and 152°. Therefore, an angle below 142° is indicative of micrognathia. However, FNMA has a lower positive predictive value; many normal fetuses can have a frontonasal-mental angle less than 142°. Recent literature suggests that in pathological cases, the frontonasal-mental angle ranges from 100° to 134°. For example, according to Cang et al. [2023], an FNMA <135.91° can be used as a diagnostic criterion for micrognathia during prenatal examination. The average FNMA measurement in our study sample at T0 was 134.8°, with three infants having an angle <134°, although their IFA measurements were well above the micrognathia diagnostic threshold. In general, there are no studies measuring FNMA in neonates; however, analysing our study's T1 results showed an average measurement >134°. Therefore, in all five cases, the angle exceeded the reference range considered for micrognathia diagnosis. Furthermore, the average change (ΔT0-T1) was

	IFA	FNMA	IPD	LL	HC
Wilcoxon	7,5	3,5	0	0	0
p-value	1	0,3125	0,0625	0,0625	0,0625
Cohen's d	-0,06	0,49	1,27	2,37	4,52
CI L	-8,38	-6,39	0,04	0,7	1,42
CI U	7,38	14,79	4,56	2,22	2,5

TABLE 3 Wilcoxon test, p-value, Cohen's d, 95% confidence interval limits.

+4.2°; specifically, the angle increased in infants where T0 was <134°, while decreasing in the other two cases where T0 FNMA was >134°.

Regarding Interpupillary Distance (IPD), all cases showed an increase, with an average change (ΔT0-T1) of +2.3 cm. The study by Morrison et al. [1984] measured this parameter in children aged 0 to 6 years, reporting an average of about 4.3 cm at birth. Kulkarni et al. [1992] also provided detailed IPD data, aiming to establish ranges for various ocular measurements in neonates and fetuses of different gestational ages, with birth values averaging around 4.07 ± 2.4 (SD). IPD in fetuses is less frequently reported than in neonates, but there are prenatal ultrasound and imaging studies investigating fetal facial dimensions. For instance, Kulkarni et al. [1992] established that IPD at 37 weeks of gestation averaged 3.69 cm ± 3.2 (SD). Examining our study's results, the average IPD measurement at T0 was 3.7 cm ± 0.29 (SD), increasing to 6 cm ± 1.55 (SD) at T1. Thus, the measurement at 37 weeks of gestation closely aligns with Kulkarni's study [1992], while the average IPD at birth in our sample was approximately 1.5 - 2 cm higher than those reported in the aforementioned articles.

Concerning Lip-to-Lip Distance (LL), all five cases showed an increase between the measurement taken at 37 weeks of gestation and that recorded on the second day of life, specifically with an average change (ΔT0-T1) of +1.5 cm. Chae et al. [2006] divided healthy neonates into four groups: under 2 weeks old, 60 ± 7 days, 120 ± 7 days, and 180 ± 7 days. Each group comprised 40 children, with linear distances including 13 elements related to the nose, mouth, and lips. Particularly, the mean intercommissural distance for the under 2-week-old group was 2.68 cm. In our study, the average LL measurement at T1 was 4 cm, while at T0 it was 2.5 cm; thus, the ultrasound measurement closely approximates the Chae et al. study [2006] for the under 2-week-old group. There is currently no literature evaluating LL during the 37th week of life through ultrasound, so comparisons cannot be made.

Cranial circumference (CC) is an important measure for assessing neonatal growth and development, often monitored regularly during the first few months of life. The World Health Organization (WHO) conducted various studies to establish growth standards, including cranial circumference. According to WHO data [Farronato et al.,2022; Farronato et al., 2012; Abate et al., 2020], the average cranial circumference for a fetus at 37 weeks of gestation is approximately 33.5 cm. Davidson et al. [2008], in their study on individuals born in Israel between 1991 and 2005 during the 37th week of pregnancy, reported an average circumference of 33 cm for females and 34 cm for males. According to our study's data, at T0, cranial circumference (CC) in females was 32.3 cm, while in males it was around 31.9 cm. This value is slightly lower than those reported in the two aforementioned studies. Additionally, it is important to note that, from the results obtained in our study, the average cranial circumference was marginally higher in females than in males, contrary to the findings of Davidson et al. [2008]. The WHO Multicentre Growth Reference Study (MGRS) [Maspero et al., 2020; Farronato et al., 2009; Botzer et al., 2021] is one of the key projects that collected anthropometric data from various global populations to create infant growth standards. According to this study, average cranial circumference in newborns varies slightly by gender, with mean values around 34.5 cm for male and 33.9 cm for female neonates. As shown in our study results, head circumference at birth in the sample of patients under study is 34.1 cm for both females and males, closely aligning with the proposed values for females.

Study Limitations

The number of participants involved in this pilot study was limited primarily due to challenges encountered during the recruitment phase. Despite initially considering more than five pregnant women, difficulty arises in finding fetuses at 37 weeks of gestation in a favorable position to allow for the collection of necessary facial measurements via ultrasound; two cases were excluded from the research due to complications necessitating emergency cesarean sections. In addition, there are limitations due to the plasticity of bones in newborns, which can alter measurements in the days immediately following birth.

Conclusions

Compared to intrauterine analyses, the evaluated postpartum parameters had undergone changes in almost half of the sample, which provide important reflections on prenatal malocclusion diagnosis. Given the small sample size, these results are interesting but not completed and should be interpreted with caution. Further researches are desirable, significantly expanding the study sample and following subjects over more time.

Acknowledgements and funding

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and authorised by the Ospedale Maggiore Policlinico, Current Research, Operative Unit 420/425, Progressive number project 3.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest

The authors declare no conflict of interest.

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