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ORIGINAL ARTICLE / ARAŞTIRMA MAKALESİ

Retrospective Analysis of Cone Beam Computed Tomography Referrals in a Paediatric and Adolescent Patient Subgroup

Pediatrik ve Adolesan Hasta Grubunda Konik Işınlı Bilgisayarlı Tomografi Endikasyonlarının Retrospektif Analizi

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ABSTRACT

Objectives: This study was aimed to evaluate the cone beam computed tomography (CBCT) indications in paediatric and adolescent patients and to investigate their compliance with the guidelines set by the DIMITRA (dentomaxillofacial paediatric imaging: an investigation toward low-dose radiation induced risks) Project.

Materials and Methods: CBCT images of paediatric and adolescent patients were selected and evaluated among a total of 12494 CBCT images reviewed retrospectively. Data regarding age, gender, referring department, field of view (FOV), and CBCT indications were recorded. Based on an adaptation of European DIMITRA Project recommendations, CBCT indications were categorized as impacted teeth, trauma, orofacial clefts, dental anomalies, bone pathology, syndromes, and other indications. Follow-up CBCT examinations and incidental findings were also recorded. Data were statistically analyzed at p<0.05 significance level.

Results: Most of the 1686 CBCT scans obtained from paediatric and adolescent patients were referred from the Department of Oral and Maxillofacial Radiology (31.2%), followed by the Departments of Orthodontics (25.9%) and Oral and Maxillofacial Surgery (24.6%). The most frequently requested FOV was the maxilla (35.1%) followed by the jaws (maxilla-mandible) (29.3%) and the maxillary canine-incisor region was the most commonly requested region among localised applications (83.1%). The most common indication was impacted teeth (33.5%) followed by bone pathology (32.7%). Follow-up CBCT examinations were recorded mostly for syndromes (33.3%) and orofacial clefts (20.4%).

Conclusions: The use of CBCT should be justified on a patient basis and DIMITRA Project recommendations can guide dental professionals in referring CBCT in paediatric and adolescent population.

Keywords: cone beam computed tomography, indication, paediatric, adolescent

ÖZ

Amaç: Bu retrospektif çalışmada, pediatrik ve adolesan hastalarda konik ışınlı bilgisayarlı tomografi (KIBT) endikasyonlarının değerlendirilmesi ve DIMITRA (dentomaxillofacial paediatric imaging: an investigation toward low-dose radiation induced risks) Projesi ile belirlenen kılavuza uygunluğunun araştırılması amaçlanmıştır.

Gereç ve Yöntemler: Retrospektif olarak incelen toplam 12494 KIBT görüntüsü arasından pediatrik ve adolesan hastaların KIBT görüntüleri seçilmiş ve değerlendirilmiştir. Yaş, cinsiyet, sevk eden bölüm, görüntüleme alanı (FOV) ve KIBT endikasyonlarına ilişkin veriler kaydedilmiştir. Avrupa DIMITRA Projesi önerilerinin modifikasyonuna dayanarak KIBT endikasyonları gömülü dişler, travma, orofasiyal yarıklar, dental anomaliler, kemik patolojisi, sendromlar ve diğer endikasyonlar olarak kategorize edilmiştir. Takip KIBT incelemeleri ve tesadüfi bulgular da kaydedilmiştir. Veriler istatistiksel olarak p<0,05 anlamlılık düzeyinde analiz edilmiştir.

Bulgular: Pediatrik ve adolesan hastalardan alınan 1686 adet KIBT görüntüsünün çoğu Ağız, Diş ve Çene Radyolojisi Anabilim Dalı'ndan (%31,2) istenmiş olup, bunu Ortodonti (%25,9) ve Ağız, Diş ve Çene Cerrahisi Anabilim Dalları (%24,6) izlemiştir. En sık istenen FOV maksilla (%35,1) olup, bunu çeneler (maksilla-mandibula) (%29,3) takip etmiştir. Lokalize uygulamalar arasında en sık istenen bölge maksiller kanin-kesici bölge (%83,1) olarak saptanmıştır. En sık görülen KIBT endikasyonu gömülü dişler (%33,5) olup, bunu kemik patolojisi (%32,7) izlemiştir. Takip KIBT incelemeleri çoğunlukla sendromlar (%33,3) ve orofasiyal yarıklar (%20,4) için istenmiştir.

Sonuç: KIBT kullanımı hasta bazında gerekçelendirilmelidir ve DIMITRA Projesi tavsiyeleri diş hekimlerine pediatrik ve adolesan popülasyonda KIBT endikasyonlarında rehberlik edebilir.

Anahtar Kelimeler: konik ışınlı bilgisayarlı tomografi, endikasyon, pediatrik, adolesan

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INTRODUCTION

Cone-beam Computed Tomography (CBCT), which provides high-quality three-dimensional (3D) images of the maxillofacial region, has been widely used in different branches of dentistry in recent years (Aytugar et al., 2019). The radiation doses and risks of dental CBCT, which are generally higher than conventional dental radiography and much lower than computed tomography (CT), vary depending on the device type, exposure parameters, and in particular on the selected field of view (FOV) (Liang et al., 2010; Li et al., 2013; Aytugar et al., 2019).

The widespread use of CBCT has raised concerns about the radiation dose that patients are exposed to (Scarfe, 2012). Since cell growth and organ development in children are more sensitive to radiation than in adults, particular attention should be paid to radiation protection during the use of CBCT (Alamri et al., 2012; Scarfe, 2012; Isman et al., 2017; Hedesiu et al., 2018). The use of CBCT, of which the routine use is contraindicated in the paediatric population, should be justified on a patient basis (Aps, 2013).

In 2018, within the scope of the European DIMITRA Project (*dentomaxillofacial paediatric imaging: an investigation toward low-dose radiation induced risks*), which is a part of the OPERRA research (*Open Project for European Radiation Research Area*), a position statement aiming to establish patient-specific and indication-oriented recommendations and clinical guidelines for the appropriate use of CBCT in paediatric dentistry was published (Oenning et al., 2018). The DIMITRA consortium aimed to move from ALARA (As Low As Reasonably Achievable) and ALADA (As Low As Diagnostically Acceptable) to ALADAIP (As Low As Diagnostically Acceptable being Indication-oriented and Patient-specific) (Oenning et al., 2018). CBCT examinations should be recommended only in clinical situations where the information obtained may change the diagnosis or improve the treatment plan (Radiation Protection No. 172, 2012; Hedesiu et al., 2018).

Since the number of studies investigating the CBCT indications in paediatric and adolescent populations is scarce (Suzuki et al., 2006; Hidalgo-Rivas et al., 2014; Van Acker et al., 2016; Isman et al., 2017; Mizban et al., 2019; Gallichan et al., 2020; Hajem et al., 2020; Gumru et al., 2021; Henein et al., 2021), this retrospective CBCT study was aimed to evaluate the CBCT indications in paediatric and adolescent patients admitted to Marmara University Faculty of Dentistry and to investigate their compliance with the guidelines established by the DIMITRA Project.

MATERIALS AND METHODS

A total of 12494 CBCT images obtained from patients who admitted to Oral and Maxillofacial Radiology Department of Marmara University Faculty of Dentistry between January 2013 and December 2020 were retrospectively analysed and CBCT images of paediatric and adolescent patients under the age of 18 were included in the study group. All available CBCT images used in this study were obtained with a Planmeca Promax 3D Mid volumetric tomography device (Planmeca Oy, Helsinki, Finland).

Data regarding age, gender, referring department, FOV size, and CBCT indications of the paediatric and adolescent patient subgroup were recorded.

Age was calculated by subtracting the patient's date of birth from the CBCT imaging date. Referring departments were categorized as orthodontics, oral and maxillofacial radiology, paediatric dentistry, oral and maxillofacial surgery, endodontics, and periodontology. FOV sizes of the CBCT scans were categorized into face, jaws (maxilla-mandible), maxilla, mandible, and regional. Regional CBCT scans were further recorded as 4 different regions as maxillary molar-premolar, maxillary canine-incisor, mandibular molar-premolar, and mandibular canine-incisor.

CBCT indications for the paediatric and adolescent subgroup under 18 years of age were categorized and recorded as impacted teeth, trauma, orofacial clefts, dental anomalies, bone pathology, and syndromes using an adaptation of the European DIMITRA Project recommendations. An additional "other" heading was added for CBCT referral reasons unclassified in the DIMITRA Project. When multiple indications were identified for the CBCT examination, each was recorded individually.

While evaluating the CBCT images, the findings not related to the reason for the CBCT referral were considered as "incidental findings" and recorded. The number of follow-up CBCT examinations, if any, was also noted. In the event of a CBCT retake, the retake was included in the assessment.

In this study, all evaluations were made under standard conditions by a single researcher (SD) and double-checked. The same medical monitor (NEC MD242C2 24-inch monitor, 1920×1200 resolution, Hiliex Advanced Medical

Technologies, California, USA) was used for all analyzes with a black background and dim lighting.

For the statistical analysis, IBM® SPSS Statistics 22 (IBM SPSS, Turkey) program was used. In addition to descriptive statistical methods (mean, standard deviation, frequency), chi-square and Fisher Freeman Halton Exact tests were used in the comparison of qualitative data with a significance level of $p<0.05$.

The design of this retrospective study was reviewed and approved by the Clinical Research Ethics Committee of Marmara University Faculty of Medicine (Protocol number: 09.2021.91).

RESULTS

In this study, a total of 1686 CBCT scans obtained from 803 girls (47.6%) and 883 boys (52.4%) younger than 18 years were evaluated retrospectively. The ages of the patients in the study group ranged from 2 to 17, with a mean age of 13.59±3.04 years.

Referring Departments and CBCT FOV Sizes

Table 1 shows the distribution of CBCT scans in regard to referring departments, FOV sizes, and regional FOVs. CBCT referrals were mostly from Department of Oral and Maxillofacial Radiology (n=526, 31.2%). The most commonly referred FOV size was maxilla (n=592, 35.1%) and the most commonly referred regional FOV was maxillary canine-incisor region (n=138, 83.1%).

Table 1. Distribution of CBCT scans in regard to referring departments, FOV sizes, and regional FOVs

		n	%
CBCT Referring Department	Orthodontics	437	25.9
	Oral and Maxillofacial Radiology	526	31.2
	Paediatric Dentistry	286	17.0
	Oral and Maxillofacial Surgery	415	24.6
	Endodontics	20	1.2
	Periodontology	2	0.1
FOV Sizes	Face	121	7.2
	Jaws (maxilla-mandible)	494	29.3
	Maxilla	592	35.1
	Mandible	313	18.6
	Regional	166	9.8
Regional FOVs	Maxillary molar-premolar	7	4.2
	Maxillary canine-incisor	138	83.1
	Mandibular molar-premolar	13	7.8
	Mandibular canine-incisor	8	4.8

The distribution of CBCT FOV sizes in regard to the referring departments is shown in Table 2. Statistically significant differences were detected in the distribution of FOV sizes in regard to the CBCT referring departments (p:0.001; $p<0.05$). The "face" and "maxilla" FOV size referrals from the Department of Orthodontics (12.1% and 50.1%, respectively) were significantly higher than the other departments ($p<0.05$). The "jaws" FOV size referrals from the Department of Paediatric Dentistry (6.6%) were found to be significantly lower than the Departments of Oral and Maxillofacial Radiology (38%) and Surgery (32.8%) (p_1:0.001; p_2:0.001; $p<0.05$). In addition, the "regional" FOV size referrals from the Department of Endodontics (55%) were found to be significantly higher than the Departments of Oral and Maxillofacial Radiology (2.5%) and Surgery (2.2%) (p_1:0.001; p_2:0.001; $p<0.05$). As for the regional FOV referrals, "maxillary canine-incisor" region referrals from the Department of Paediatric Dentistry (90.6%) were higher than the Departments of Orthodontics (40%), Oral and Maxillofacial Radiology (38.5%), and Surgery (66.7%) (p_1:0.001; p_2:0.001; p_3:0.001; $p<0.05$).

Table 2. Distribution of CBCT FOV sizes in regard to the referring departments

FOV Sizes	CBCT Referring Department: Orthodontics n (%)	Oral and Maxillofacial Radiology n (%)	Paediatric Dentistry n (%)	Oral and Maxillofacial Surgery n (%)	Endodontics n (%)	*p*
Face	53 (12.1%)	23 (4.4%)	11 (3.8%)	34 (8.2%)	0 (0%)	0.001*
Jaws (maxilla-mandible)	138 (31.6%)	200 (38%)	19 (6.6%)	136 (32.8%)	1 (5%)	
Maxilla	219 (50.1%)	132 (25.1%)	111 (38.8%)	122 (29.4%)	7 (35%)	
Mandible	22 (5%)	158 (30%)	17 (5.9%)	114 (27.5%)	1 (5%)	
Regional	5 (1.1%)	13 (2.5%)	128 (44.8%)	9 (2.2%)	11 (55%)	
Maxillary molar-premolar	1 (20%)	0 (0%)	4 (3.1%)	1 (11.1%)	1 (9.1%)	0.001*
Maxillary canine-incisor	2 (40%)	5 (38.5%)	116 (90.6%)	6 (66.7%)	9 (81.8%)	
Mandibular molar-premolar	2 (40%)	5 (38.5%)	3 (2.3%)	2 (22.2%)	1 (9.1%)	
Mandibular canine-incisor	0 (0%)	3 (23.1%)	5 (3.9%)	0 (0%)	0 (0%)	

Chi-square test *p<0.05

Referring Departments and CBCT Indications

It was obvious that the total number of indications (n=1939) was higher than the total number of patients because CBCT referrals in some patients were for multiple clinical conditions.

The orthodontic CBCT referrals due to orofacial clefts (32.3%), pedodontic referrals due to impacted teeth and dental anomalies (51% and 50.3%, respectively), and endodontic referrals due to trauma (15%) were found to be significantly higher in comparison to the other departments (p<0.05) (Table 3).

Table 3. Distribution of the CBCT indications in regard to the referring departments

CBCT Referring Department	CBCT Indications						
	Impacted teeth	**Trauma**	**Orofacial clefts**	**Dental anomalies**	**Bone pathology**	**Syndromes**	**Other**
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Orthodontics	173 (39.6%)	3 (0.7%)	141 (32.3%)	63 (14.4%)	20 (4.6%)	1 (0.2%)	83 (19%)
Oral and Maxillofacial Radiology	112 (21.3%)	38 (7.2%)	9 (1.7%)	62 (11.8%)	262 (49.8%)	1 (0.2%)	74 (14.1%)
Paediatric Dentistry	146 (51.0%)	21 (7.3%)	2 (0.7%)	144 (50.3%)	89 (31.1%)	0 (0%)	2 (0.7%)
Oral and Maxillofacial Surgery	131 (31.6%)	17 (4.1%)	10 (2.4%)	93 (22.4%)	167 (40.2%)	1 (0.2%)	49 (11.8%)
Endodontics	1 (5%)	3 (15%)	0 (0%)	7 (35%)	12 (60%)	0 (0%)	0 (0%)
p	0.001*	0.001*	0.001*	0.001*	0.001*	+1.000	0.001*

Chi-square test Fisher Freeman Halton Exact test *p<0.05

CBCT Indications and CBCT FOV Sizes

The most frequently referred CBCT FOV size was "maxilla" for impacted teeth (45.4%), "face" for orofacial clefts (28.9%), "regional" for dental anomalies (47.6%), "mandibula" for bone pathology (66.8%), "face" for trauma (11.6%), and "jaws" for other indications (28.5%) (p<0.05).

Among regional FOVs, maxillary canine-incisor region referrals were observed to be statistically significantly lower for bone pathology (25.4%) and higher for dental anomaly (53.6%) indications (p<0.05) (Table 4).

Table 4. Distribution of the CBCT indications in regard to FOV sizes

FOV Sizes	CBCT Indications						
	Impacted teeth	**Trauma**	**Orofacial clefts**	**Dental anomalies**	**Bone pathology**	**Syndromes**	**Other**
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Face	24 (19.8%)	14 (11.6%)	35 (28.9%)	17 (14%)	23 (19%)	1 (0.8%)	26 (21.5%)
Jaws (maxilla-mandible)	127 (25.7%)	40 (8.1%)	55 (11.1%)	76 (15.4%)	104 (21.1%)	2 (0.4%)	141 (28.5%)
Maxilla	269 (45.4%)	8 (1.4%)	70 (11.8%)	157 (26.5%)	159 (26.9%)	0 (0%)	31 (5.2%)
Mandible	83 (26.5%)	4 (1.3%)	1 (0.3%)	40 (12.8%)	209 (66.8%)	0 (0%)	9 (2.9%)
Regional	61 (36.7%)	16 (9.6%)	1 (0.6%)	79 (47.6%)	56 (33.7%)	0 (0%)	1 (0.6%)
p	0.001*	0.001*	0.001*	0.001*	0.001*	+0.119	0.001*
Maxillary molar-premolar	2 (28.6%)	0 (0%)	0 (0%)	0 (0%)	6 (85.7%)	0 (0%)	0 (0%)
Maxillary canine-incisor	55 (39.9%)	15 (10.9%)	1 (0.7%)	74 (53.6%)	35 (25.4%)	0 (0%)	1 (0.7%)
Mandibular molar-premolar	2 (15.4%)	1 (7.7%)	0 (0%)	4 (30.8%)	8 (61.5%)	0 (0%)	0 (0%)
Mandibular canine-incisor	2 (25%)	0 (0%)	0 (0%)	1 (12.5%)	7 (87.5%)	0 (0%)	0 (0%)
p	+0.307	+1.000	+1.000	+0.002*	+0.001*	-	+1.000

Chi-square test Fisher Freeman Halton Exact test *p<0.05

Of a total of 1686 paediatric and adolescent patients, 160 (9.5%) had follow-up CBCT scans mostly for orofacial clefts and syndromes. Of these, 132 patients received 1, 22 patients received 2, 4 patients received 3, and 2 patients received 4 follow-up CBCT examinations. In addition, a total of 738 incidental findings, most of which were related to sinuses (93.1%), were encountered.

DISCUSSION

There are a limited number of original research articles concerning CBCT referrals in paediatric and/or adolescent patients (Suzuki et al., 2006; Hidalgo-Rivas et al., 2014; Van Acker et al., 2016; Isman et al., 2017; ; Mizban et al., 2019; Gallichan et al., 2020; Hajem et al., 2020; Gumru et al., 2021; Henein et al. 2021) (Table 5). The comparison of the findings of our study with the previous studies seems impossible due to the different methodologies and equipments used.

Table 5. Previous similar studies listed in chronological order with author(s), country, age range of the patients, CBCT device, most frequent CBCT indication, and most frequent CBCT FOV size

Author(s) (year)	Country	Age Range	CBCT Device	Most Frequent CBCT Indication	Most Frequent CBCT FOV Size
Suzuki et al. (2006)	Japan	-	-	Impacted supernumerary teeth (51%)	-
Hidalgo-Rivas et al. (2014)	UK	5-17	NewTom VG, 3D Accuitomo 170, and i-Cat Next Generation	Ectopic impacted canine (33.9%)	Maxilla anterior (63.4%)
Van Acker et al. (2016)	Belgium	7-17	Planmeca Promax® 3D Max	Impacted canine (14%)	Small (50x55mm) (81%)
Isman et al. (2017)	Turkey	2-17	Planmeca Promax® 3D Mid	Malocclusion and dentofacial anomalies in primary and permanent dentition (38.5%)	Face (74%)
Mizban et al. (2019)	UK	5-17	-	Unerupted teeth (23%)	-
Gallichan et al. (2020)	UK	3-16	-	Localised developing dentition (46%)	Maxilla anterior (68%)
Hajem et al. (2020)	Sweden	6-18	3D Accuitomo 170	Ectopic canine (38.6%)	Small (40x40 mm) (48%)
Gumru et al. (2021)	Turkey	3-14	Planmeca Promax® 3D Mid	Impacted teeth (41.4%)	Maxilla (33.4%)
Henein et al. (2021)	UK	7-16	Instrumentarium Orthopantomograph OP300 Maxio	Impacted teeth (44%)	Small (50x50mm) (73%)
Deveci&Gumru (2022)	Turkey	2-17	Planmeca Promax® 3D Mid	Impacted teeth (33.5%)	Maxilla (35.1%)

The most common reasons for CBCT referral in children and adolescents in Japan were reported to be impacted supernumerary teeth, disorders of tooth eruption, and evaluation of the temporomandibular joint in the first study on this topic in the literature by Suzuki et al. (2006).

Hidalgo-Rivas et al. (2014) reported the most common reason for CBCT referral in paediatric and adolescent patient group in United Kingdom (UK) as unerupted canine localization and detection of adjacent root resorption. Most of the CBCT examinations were regional (81.5%) and included maxillary anterior region (63.4%). In addition, incidental findings were mostly inflammatory sinonasal diseases.

Similarly, unerupted canine localization and detection of adjacent root resorption were reported as the most common reasons for CBCT referral in children and adolescents at a university hospital in Belgium by Van Acker et al. (2016). CBCT examinations were mostly performed with a small FOV of 50x55 mm (81%).

Isman et al. (2017) reported that the most frequent indications for CBCT in Turkish children and adolescents were malocclusion and dentomaxillofacial anomalies in the primary and permanent dentition groups and impacted teeth localisation in the mixed dentition group. Additionally, the most frequently referred FOV was reported as face (20x17cm) (74%).

CBCT examinations were reported to be most frequently requested for the assessment of unerupted teeth (23%), supernumerary teeth (21%), and bony pathosis (20%) in a paediatric dentistry department in London in a retrospective study conducted by Mizban et al. (2019).

Gallichan et al. (2020) investigated the CBCT referral profile in three UK paediatric dentistry departments and reported the most frequent indication for CBCT as the assessment of localised developing dentition (46%). In addition, the most frequently referred FOV was reported as "maxilla anterior" (20x17cm) (68%).

A retrospective study by Hajem et al. (2020) provided useful information on the use of CBCT in paediatric and adolescent population in a private maxillofacial radiology centre in Sweden. The most common reason for CBCT referral was the assessment of ectopic canine and potential resorption in adjacent teeth. The most commonly referred FOV was 40x40mm (48%). Of the CBCT requests, 43% were from general practitioners, 26% from orthodontists, 20% from maxillofacial surgeons, 7% from paediatric dentists, 2.6% from endodontists and prosthodontists, and 1.4% from medical doctors.

In a recent study by Gumru et al. (2021) in the Turkish paediatric subpopulation, an adaptation of the European DIMITRA project recommendations was used. The most common CBCT indication was reported as impacted teeth followed by bone pathology and dental anomalies. Most of the CBCT referrals were from the Department of Paediatric Dentistry (36.3%) and the most frequently referred FOV was maxilla (33.4%).

Similar to the previous studies, the most common CBCT indication was reported as localization of unerupted/ectopic/impacted teeth and the most commonly referred FOV was reported as 50x50mm (73%) in a paediatric dentistry department in a UK dental hospital by Henein et al. (2021).

In the present study, the age range of the paediatric and adolescent patient group was 2-17 years. The most frequently referred FOV size was detected to be "maxilla" similar to the findings of Gumru et al. (2021). Similar to the results of most of the previous studies, the most frequently referred regional FOV was "anterior maxilla" (Hidalgo-Rivas et al., 2014; Gallichan et al., 2020; Gumru et al., 2021). Classifying the CBCT indications according to an adaptation of the European DIMITRA project recommendations, the most common CBCT indication was impacted teeth similar to previous studies (Hidalgo-Rivas et al., 2014; Van Acker et al., 2016; Mizban et al., 2019; Hajem et al., 2020; Gumru et al., 2021; Henein et al., 2021). As reported by Hidalgo-Rivas et al. (2014) and Gumru et al. (2021), the most common incidental finding was sinonasal diseases.

CONCLUSION

CBCT plays an important role in almost all branches of dentistry from the diagnostic process to the treatment planning and outcome evaluation and should only be prescribed when the benefits outweigh the inherent risks. As a general rule, CBCT scanning should be performed if the use of CBCT is required to improve treatment planning and treatment outcomes (Adibi et al., 2012; Radiation Protection No. 172, 2012). Consequently, when CBCT is required for children and adolescents, the indications should be justified.

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AUTHOR CONTRIBUTIONS

SD and BG; contributed to study conception and design, collaborated for data collection, and drafted the manuscript. Both authors reviewed and approved the manuscript.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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