UDK 37

INTERNATIONAL JOURNAL

ISSN 2545 - 4439 ISSN 1857 - 923X

Institute of Knowledge Management

KNOWLEDGE 🍁 🙏





INTERNATIONAL JOURNAL

SCIENTIFIC PAPERS VOL. 69.4

April, 2025

INSTITUTE OF KNOWLEDGE MANAGEMENT SKOPJE



KNOWLEDGE International Journal Scientific Papers Vol. 69.4

ADVISORY BOARD

Vlado Kambovski PhD, Robert Dimitrovski PhD, Siniša Zarić PhD, Maria Kavdanska PhD, Mirjana Borota – Popovska PhD, Veselin Videv PhD, Ivo Zupanovic PhD, Savo Ashtalkoski PhD, Zivota Radosavljević PhD, Laste Spasovski PhD, Mersad Mujevic PhD, Milka Zdravkovska PhD, Drago Cvijanovic PhD, Predrag Trajković PhD, Lazar Stosic PhD, Krasimira Staneva PhD, Nebojsha Pavlović PhD, Daniela Todorova PhD, Lisen Bashkurti PhD, Zoran Srzentić PhD, Itska Derijan PhD, Sinisa Opic PhD, Marija Kostic PhD

Print: GRAFOPROM – Bitola

Editor: IKM – Skopje

Editor in chief Robert Dimitrovski, PhD

KNOWLEDGE - International Journal Scientific Papers Vol. 69.4

ISSN 1857-923X (for e-version) ISSN 2545 – 4439 (for printed version)

INTERNATIONAL EDITORIAL BOARD

President: Academic Prof. Vlado Kambovski PhD, Skopje (N. Macedonia)

Vice presidents:

Prof. Robert Dimitrovski PhD, Institute of Knowledge Management, Skopje (N. Macedonia) Prof. Sinisa Zaric, PhD, Faculty of Economics, University of Belgrade, Belgrade (Serbia) Prof. Mersad Mujevic PhD, Public Procurement Administration of Montenegro (Montenegro)

Members:

- Prof. Azra Adjajlic Dedovic PhD, Faculty of criminology and security, Sarajevo (Bosnia & Herzegovina)
- Prof. Aleksandar Korablev PhD, Faculty of economy and management, Saint Petrsburg State Forest Technical University, Saint Petrsburg (Russian Federation)
- Prof. Anita Trajkovska PhD, Rochester University (USA)
- Prof. Aziz Pollozhani PhD, Rector, University Mother Teresa, Skopje (N.Macedonia)
- Prof. Anka Trajkovska-Petkoska PhD, UKLO, Faculty of technology and technical sciences, Bitola (N. Macedonia)
- Prof. Aneta Mijoska PhD, Faculty of Dentistry, University "St. Cyril and Methodius", Skopje (N. Macedonia)
- Prof. Alisabri Sabani PhD, Faculty of criminology and security, Sarajevo (Bosnia & Herzegovina)
- Prof. Artan Nimani PhD, Rector, University of Gjakova "Fehmi Agani" (Kosovo)
- Prof. Ahmad Zakeri PhD, University of Wolverhampton, (United Kingdom)
- Prof. Ana Dzumalieva PhD, South-West University "Neofit Rilski", Blagoevgrad (Bulgaria)
- Prof. Branko Sotirov PhD, University of Rousse, Rousse (Bulgaria)
- Prof. Branko Boshkovic, PhD, College of Sports and Health, Belgrade (Serbia)
- Prof. Branimir Kampl PhD, Institute SANO, Zagreb (Croatia)
- Prof. Branislav Simonovic PhD, Faculty of Law, Kragujevac (Serbia)
 Prof. Bistra Angelovska, Faculty of Medicine, University "Goce Delcev", Shtip (N.Macedonia)
- Prof. Cezar Birzea, PhD, National School for Political and Administrative Studies, Bucharest (Romania)
- Prof. Cvetko Andreevski, Faculty of Tourism, UKLO, Bitola (N.Macedonia)
- Prof. Drago Cvijanovic, PhD, Faculty of Hotel Management and Tourism, University of Kragujevac, Vrnjacka Banja (Serbia)
- Prof. Dusan Ristic, PhD Emeritus, College of professional studies in Management and Business Communication, Novi Sad (Serbia)
- Prof. Darijo Jerkovic PhD, Faculty of Business Economy, University "Vitez", (Bosnia & Herzegovina)
- Prof. Daniela Todorova PhD, "Todor Kableshkov" University of Transport, Sofia (Bulgaria)
- Prof. Dragan Kokovic PhD, University of Novi Sad, Novi Sad (Serbia)
- Prof. Dragan Marinkovic PhD, High health sanitary school for professional studies, Belgrade (Serbia)
- Prof. Itska Mihaylova Derijan PhD, University Neofit Rilski, Faculty of pedagogy, Blagoevgrad (Bulgaria)
- Prof. Dzulijana Tomovska, PhD, Faculty of Biotechnical sciences, Bitola (N.Macedonia)
- Prof. Evgenia Penkova-Pantaleeva PhD, UNWE -Sofia (Bulgaria)
- Prof. Fadil Millaku, PhD, University "Hadzi Zeka", Peja (Kosovo)

- Prof. Fatos Ukaj, University "Hasan Prishtina", Prishtina (Kosovo)
- Prof. Georgi Georgiev PhD, National Military University "Vasil Levski", Veliko Trnovo (Bulgaria)
- Prof. Halit Shabani, PhD, University "Hadzi Zeka", Peja (Kosovo)
- Prof. Halima Sofradzija, PhD, University of Sarajevo, Saraevo (Bosnia and Herzegovina)
- Prof. Haris Halilovic, Faculty of criminology and security, University of Sarajevo, Saraevo (Bosnia and Herzegovina)
- Prof. Helmut Shramke PhD, former Head of the University of Vienna Reform Group (Austria)
- Prof. Hristina Georgieva Yancheva, PhD, Agricultural University, Plovdiv (Bulgaria)
- Prof. Hristo Beloev PhD, Bulgarian Academy of Science, Rector of the University of Rousse (Bulgaria)
- Prof. Hristina Milcheva, Medical college, Trakia University, Stara Zagora (Bulgaria)
- Prof. Izet Zeqiri, PhD, Academic, SEEU, Tetovo (N.Macedonia)
- Prof. Ivan Marchevski, PhD, D.A. Tsenov Academy of Economics, Svishtov (Bulgaria)
- Prof. Ibrahim Obhodjas PhD, Faculty of Business Economy, University "Vitez", (Bosnia & Herzegovina)
- Doc. Igor Stubelj, PhD, PhD, Faculty of Management, Primorska University, Koper (Slovenia)
- Prof. Ivo Zupanovic, PhD, Faculty of Business and Tourism, Budva (Montenegro)
- Prof. Ivan Blazhevski, PhD, Institute for Sociological, Political and Juridical Research, Skopje (N.Macedonia)
- Prof. Isa Spahiu PhD, International Balkan University, Skopje (N. Macedonia)
- Prof. Ivana Jelik PhD, University of Podgorica, Faculty of Law, Podgorica (Montenegro)
- Prof. Islam Hasani PhD, Kingston University (Bahrein)
- Prof. Jamila Jaganjac PhD, Faculty of Business Economy, University "Vitez", (Bosnia & Herzegovina)
- Prof. Jova Ateljevic PhD, Faculty of Economy, University of Banja Luka, (Bosnia & Herzegovina)
- Prof. Jonko Kunchev PhD, University "Cernorizec Hrabar" Varna (Bulgaria)
- Prof Karl Schopf, PhD, Akademie fur wissenschaftliche forchung und studium, Wien (Austria)
- Prof. Katerina Belichovska, PhD, Faculty of Agricultural Sciences, UKIM, Skopje (N. Macedonia)
- Prof. Krasimir Petkov, PhD, National Sports Academy "Vassil Levski", Sofia (Bulgaria)
- Prof. Kamal Al-Nakib PhD, College of Business Administration Department, Kingdom University (Bahrain)
- Prof. Kiril Lisichkov, Faculty of Technology and Metallurgy, UKIM, Skopje (N.Macedonia)
- Prof. Krasimira Staneva PhD, University of Forestry, Sofia (Bulgaria)
- Prof. Lidija Tozi PhD, Faculty of Pharmacy, Ss. Cyril and Methodius University, Skopje (N.Macedonia)
- Prof. Laste Spasovski PhD, Vocational and educational centre, Skopje (N.Macedonia)
- Prof. Larisa Velic, PhD, Faculty of Law, University of Zenica, Zenica (Bosnia and Herzegovina)
- Prof. Łukasz Tomczyk PhD, Pedagogical University of Cracow (Poland)
- Prof. Lujza Grueva, PhD, Faculty of Medical Sciences, UKIM, Skopje (N.Macedonia)
- Prof. Lazar Stosic, PhD, Association for development of science, engineering and education, Vranje (Serbia)
- Prof. Lulzim Zeneli PhD, University of Gjakova "Fehmi Agani" (Kosovo)
- Prof. Lisen Bashkurti PhD, Global Vice President of Sun Moon University (Albania)

- Prof. Lence Mircevska PhD, High Medicine School, Bitola, (N.Macedonia)
- Prof. Ljupce Kocovski PhD, Faculty of Biotechnical sciences, Bitola (N.Macedonia)
- Prof. Marusya Lyubcheva PhD, University "Prof. Asen Zlatarov", Member of the European Parliament, Burgas (Bulgaria)
- Prof. Marija Magdinceva Shopova PhD, Faculty of tourism and business logistics, University "Goce Delchev", Shtip (N. Macedonia)
- Prof. Maria Kavdanska PhD, Faculty of Pedagogy, South-West University Neofit Rilski, Blagoevgrad (Bulgaria)
- Prof. Vaska Stancheva-Popkostadinova, PhD, Faculty of Public Health and Sport, SWU Neofit Rilski, Blagoevgrad (Bulgaria)
- Prof. Mirjana Borota-Popovska, PhD, Centre for Management and Human Resource Development, Institute for Sociological, Political and Juridical Research, Skopje (N.Macedonia)
- Prof. Mihail Garevski, PhD, Institute of Earthquake Engineering and Engineering Seismology, Skopje (N.Macedonia)
- Prof. Mitko Kotovchevski, PhD, Faculty of Philosophy, UKIM, Skopje (N.Macedonia)
- Prof. Milan Radosavljevic PhD, Dean, Faculty of strategic and operational management, Union University, Belgrade (Serbia)
- Prof. Marija Topuzovska-Latkovikj, PhD, Centre for Management and Human Resource Development, Institute for Sociological, Political and Juridical Research, Skopje (N.Macedonia)
- Prof. Marija Knezevic PhD, Academic, Banja Luka, (Bosnia and Herzegovina)
- Prof. Margarita Bogdanova PhD, D.A.Tsenov Academy of Economics, Svishtov (Bulgaria)
- Prof. Mahmut Chelik PhD, Faculty of Philology, University "Goce Delchev", Shtip (N.Macedonia)
- Prof. Mihajlo Petrovski, PhD, Faculty of Medical Sciences, University "Goce Delchev", Shtip (N.Macedonia)
- Prof. Marija Mandaric PhD, Faculty of Hotel Management and Tourism, University of Kragujevac, Vrnjacka Banja (Serbia)
- Prof. Marina Simin PhD, College of professional studies in Management and Business Communication, Sremski Karlovci (Serbia)
- Prof. Miladin Kalinic, College of professional studies in Management and Business Communication, Sremski Karlovci (Serbia)
 Prof. Marijan Tanushevski PhD, Macedonian Scientific Society, Bitola (N. Macedonia)
- Prof. Mitre Stojanovski PhD, Faculty of Biotechnical sciences, Bitola (N.Macedonia)
- Prof. Miodrag Smelcerovic PhD, High Technological and Artistic Vocational School, Leskovac (Serbia)
- Prof. Nadka Kostadinova, Faculty of Economics, Trakia University, Stara Zagora (Bulgaria)
- Prof. Natalija Kirejenko PhD, Faculty For economic and Business, Institute of Entrepreneurial Activity, Minsk (Belarus)
- Prof. Nenad Taneski PhD, Military Academy "Mihailo Apostolski", Skopje (N.Macedonia)
- Prof. Nevenka Tatkovic PhD, Juraj Dobrila University of Pula, Pula (Croatia)
- Prof. Nedzad Korajlic PhD, Faculty of criminal justice and security, University of Sarajevo (Bosnia and Herzegovina)
- Prof. Nikola Sabev, PhD, Angel Kanchev University of Ruse, Ruse (Bulgaria)
- Prof. Nonka Mateva PhD, Medical University, Plovdiv (Bulgaria)
- Prof. Nikolay Georgiev PhD, "Todor Kableshkov" University of Transport, Sofia (Bulgaria)
- Prof. Nishad M. Navaz PhD, Kingdom University (India)
- Prof. Nano Ruzhin PhD, Faculty of Law, AUE-FON University, Skopje (N.Macedonia)
- Prof. Oliver Dimitrijevic PhD, High medicine school for professional studies "Hipokrat", Bujanovac (Serbia)

- Prof. Paul Sergius Koku, PhD, Florida State University, Florida (USA)
- Prof. Primoz Dolenc, PhD, Faculty of Management, Primorska University, Koper (Slovenia)
- Prof. Petar Kolev PhD, "Todor Kableshkov" University of Transport, Sofia (Bulgaria)
- Prof. Pere Tumbas PhD, Faculty of Economics, University of Novi Sad, Subotica (Serbia)
- Prof. Rade Ratkovic PhD, Faculty of Business and Tourism, Budva (Montenegro)
- Prof. Rositsa Chobanova PhD, University of Telecommunications and Posts, Sofia (Bulgaria)
- Prof. Rossana Piccolo PhD, Università degli studi della Campania Luigi Vanvitelli (Italy)
- Prof. Rumen Valcovski PhD, Imunolab Sofia (Bulgaria)
- Prof. Rumen Stefanov PhD, Faculty of public health, Medical University of Plovdiv (Bulgaria)

Prof. Rumen Tomov PhD, University of Forestry, Sofia (Bulgaria)

- Prof. Sasho Korunoski PhD, UKLO, Bitola (N.Macedonia)
- Prof. Snezhana Lazarevic, PhD, College of Sports and Health, Belgrade (Serbia)
- Prof. Vasil Markov PhD, Faculty of Arts, SWU Neofit Rilski, Blagoevgrad (Bulgaria)
- Prof. Stojna Ristevska PhD, High Medicine School, Bitola, (N. Macedonia)
- Prof. Suzana Pavlovic PhD, High health sanitary school for professional studies, Belgrade (Serbia)
- Prof. Sandra Zivanovic, PhD, Faculty of Hotel Management and Tourism, University of Kragujevac, Vrnjacka Banja (Serbia)
- Prof. Shyqeri Kabashi, College "Biznesi", Prishtina (Kosovo)
- Prof. Temelko Risteski PhD, Faculty of Law, AUE-FON University, Skopje (N. Macedonia)
- Prof. Todor Krystevich, D.A. Tsenov Academy of Economics, Svishtov (Bulgaria)
- Prof. Todorka Atanasova, Faculty of Economics, Trakia University, Stara Zagora (Bulgaria)
- Prof. Tzako Pantaleev PhD, NBUniversity, Sofia (Bulgaria)
- Prof. Vojislav Babic PhD, Institute of Sociology, University of Belgrade (Serbia)
- Prof. Volodymyr Denysyuk, PhD, Dobrov Center for Scientific and Technologogical Potential and History studies at the National Academy of Sciences of Ukraine (Ukraine)
- Prof. Valentina Staneva PhD, "Todor Kableshkov" University of Transport, Sofia (Bulgaria)
- Prof. Venus Del Rosario PhD, Arab Open University (Philippines)
- Prof. Vjollca Dibra PhD, University of Gjakova "Fehmi Agani" (Kosovo)
- Prof. Yuri Doroshenko PhD, Dean, Faculty of Economics and Management, Belgorod (Russian Federation)
- Prof. Zlatko Pejkovski, PhD, Faculty of Agricultural Sciences, UKIM, Skopje (N.Macedonia)
- Prof. Zivota Radosavljevik PhD, Faculty FORCUP, Union University, Belgrade (Serbia)
- Prof. Zorka Jugovic PhD, High health sanitary school for professional studies, Belgrade (Serbia)

REVIEW PROCEDURE AND REVIEW BOARD

Each paper is reviewed by the editor and, if it is judged suitable for this publication, it is then sent to two referees for double blind peer review.

The editorial review board is consisted of 67 members, full professors in the fields 1) Natural and mathematical sciences, 2) Technical and technological sciences, 3) Medical sciences and Health, 4) Biotechnical sciences, 5) Social sciences, and 6) Humanities from all the Balkan countries and the region.

CONTENTS

QUALITY OF LIFE OF CHILDREN AND ADOLESCENTS WITH TYPE 1 DIABETES IN	
COMPARISON TO THEIR PRIMARY CAREGIVERS	. 685
Elmedina Mrkulić	. 685
Elvedina Hodžić	. 685
Amela Idrizbegović	. 685
INCIDENCE OF DIABETES MELLITUS IN THE ZENICA-DOBOJ CANTON (2008 – 2020): A	
RETROSPECTIVE ANALYSIS	. 691
Nino Alić	. 691
Safet Hadzimusić	. 691
THE REPRESENTATION OF DIABETIC RETINOPATHY IN SHTIP	. 697
Strahil Gazepov	. 697
Jovana Koneska	. 697
KNOWLEDGE AND ATTITUDES OF HIGHER MEDICAL SCHOOL STUDENTS TOWARD	
HEPATITIS B INFECTION: A CROSS-SECTIONAL STUDY	.701
Viktorija Prodanovska Stojchevska	.701
Tanja Jovanovska	.701
Izabela Filov	.701
Angelka Jankulovska	.701
Denis Arsovski	.701
Daniela Petkovska	.701
THE ROLE OF CT PULMONARY ANGIOGRAPHY IN DETECTING RARE VASCULAR	
ANOMALIES	. 709
Sonja Nikolova	. 709
BORDERLINE BI-RADS 3 AND 4 LESIONS DETECTED BY BREAST MAGNETIC RESONAN	CE
IMAGING	.715
Nermana Ćemić	.715
Mirsad Dorić	.715
Mevlida Avdagić-Kapur	.715
REFRACTIVE SURGERY: PRINCIPLES, TECHNIQUES, AND ADVANCES	.721
Strahil Gazepov	.721
Azem Salihu	.721
KERATOCONUS TREATMENT WITH CORNEAL COLLAGEN CROSSLINKING	.727
Iljaz Ismaili	.727
Strahil Gazepov	.727
INFLUENCE OF OSTEOPOROSIS AT THE LEVEL OF THE ALVEOLAR BONE IN THE	
FRONTAL MANDIBULAR REGION	.733
Lumturije Asllani	.733
Ana Minovska	.733
Mihajlo Petrovski	.733
Merita Barani	.733
Kaltrina Aliu	.733
Elsa Hashani	.733
ASSESSMENT OF TOOTH MOVEMENT EFFICIENCY DURING CLASSICAL ORTHODONTIC	2_
AND CLEAR ALIGN THERAPY	
Fadil Azizi	.739
Cena Dimova	. 739

Vol.69.4

ANALYSIS OF THREE-DIMENSIONAL TOOTH MOVEMENT WITH FIXED APPLIANCE AN	1D
ALIGNER TREATMENT	747
Fadil Azizi	747
Cena Dimova	747
IMPROVING THE STABILITY OF BIOPHARMACEUTICALS BY APPLYING LYOPHILIZAT	ION
	753
Dragana Danilov	/53
Marjan Dzeparoski	/53
THE EFFECT OF BUPRENORPHINE THERAPY ON DEPRESSIVE SIMTOMATOLOGY IN	750
HEROIN ADDICTS	759
Aneta Spasovska Trajanovska	759
Danijela Janicevic Ivanovska	759
THE ROLE OF VITAMIN A AND ITS TOXICITY	763
Drita Havziu	763
Gjylaj Alija	763
Meral Ferati	763
MOST COMMON CAUSES OF URINARY INFECTIONS AND THEIR ANTIMICROBIAL	
RESISTANCE IN THE REGION OF CENTRAL MACEDONIA IN THE PERIOD 2022-2023	769
Keti Gjorgjieva	769
Golubinka Boshevska	769
PAP TEST AND ITS IMPORTANCE IN DETECTION AND PREVENTION OF PREMALIGNAM	ΝT
AND MALIGNANT LESIONS OF THE CERVIX	775
Šemso Rošić	775
Sulejman Kendić	775
Mirza Rošić	775
LABORATORY INDICES OF THE CAPACITY OF THE BLOOD TO TRANSPORT OXYGEN A	ΑT
NORMAL AND HIGH ALTITUDE IN ATHLETES AND PEOPLE WITH HIGH LEVEL PHYSIC	CAL
ACTIVITY	783
Kostadin Kanalev	783
Krasimir Stoykov	783
Penka Angelova	783
THE IMPACT OF REGULAR PHYSICAL TRAINING ON PHYSICAL FITNESS DURING BAS	IC
TRAINING AMONG MEMBERS OF THE ARMED FORCES OF BOSNIA AND HERZEGOVIN	[A789
Malik Burić	789
Arzija Pašalić	789
Amna Pezo	789
Mirsad Malkić	789
Azra Fočo	789
Armin Kukić	789
IMPORTANCE AND BENEFITS OF GROUP TRAINING HIGHLAND CAMPS FOR STUDENT	S
FROM THE REPRESENTATIVE SPORTS TEAMS OF THE MEDICAL UNIVERSITY OF PLOT	VDIV
	795
Krasimir Stoykov	795
Kostadin Kanalev	795
CHANCES OF PROMOTING HEALTH WORKERS ABILITIES DESPITE THE THREATS	
BROUGHT BY CHANGES IN HEALTH INSTITUTIONS ORGANIZATION IN THE REPUBLIC	COF
NORTH MACEDONIA	799
Goran Apostolski	799

SOURCES OF STRESS AND COPING BEHAVIOR AMONG HEALTH PROFESSIONALS IN	
KOSOVO	305
Nikola Georgiev	305
Batjar Halili	305
STRATEGIES FOR MANAGEMENT OF OCCUPATIONAL STRESS AMONG PUBLIC HEALTH	
INSPECTORS	311
Bahar Kadir	311
Stanislava Harizanova	311
THE INFLUENCE OF RACISM ON CLINICAL REASONING AND COMPETENCE OF NURSES	315
Kameliya Evtimova	315
Rositsa Doynovska	315

ASSESSMENT OF TOOTH MOVEMENT EFFICIENCY DURING CLASSICAL ORTHODONTIC AND CLEAR ALIGN THERAPY

Fadil Azizi

Faculty of Medical Sciences, Goce Delcev University, Stip, North Macedonia, fadilj.31159@ugd.edu.mk

Cena Dimova

Faculty of Medical Sciences, Goce Delcev University, Stip, North Macedonia, cena.dimova@ugd.edu.mk

Abstract: The process of orthodontic tooth movement is initiated by applying forces to the teeth via particular appliances that orthodontists carefully choose, place, and activate based on the identified malocclusion. The response of the teeth and their supporting tissues to these forces involves a complex biological reaction, resulting in the movement of the teeth through the surrounding structures. Conventional orthodontic treatment utilizing fixed appliances facilitates tooth movement to treat different kinds of malocclusion by employing fixed components on the surfaces of teeth, including orthodontic bands, brackets, archwires, ligatures, and abutments. The popularity of aligners in orthodontic treatment has notably increased in recent years, especially among older individuals primary because of their aesthetic advantages, comfort, and the ease of maintaining oral hygiene compared to conventional fixed braces. Regarding the importance of this issue from a clinical perspective, and because this issue is underpinned by scientific literature, we have set the following aim for this study- to compare the movement of the crown and root of the tooth between the two studied groups (traditional braces therapy and aligner therapy) after a predetermined time frame from the beginning of treatment. To achieve the defined objectives, a clinical trial was conducted at the private dental office "ALJBI ORTODENT" in Tetovo. Total number of 360 teeth from 30 subjects suffering from primary crowding malocclusion were included in this study. The study population as categorized into two groups of 15 individuals each, as follows: (1)First group: 15 patients, a total of 180 teeth, from both genders, who will be treated with a fixed appliance, DentaurumRrooth 0.22. and (2) second group: 15 patients, a total of 180 teeth, of both genders, who will be treated using an aligner, Biolon 0.75. The post-treatment digital models and the final virtual treatment plan were exported from the software as STL files and subsequently imported into Geomagic Qualify® software for comparison of the final tooth positions. Variations were calculated and analyzed for statistical significance for each tooth in the mesial-distal dimensions. For F=1.700 and p>0.05 (p=0.193) there is no significant difference between the value of the mesial-distal direction of the teeth at the beginning of the study (To), one month after treatment (T1), three months after treatment (T3), treated with a fixed appliance and an aligner. Clear aligner therapy marks a notable progression in orthodontic care, providing benefits over conventional braces, including enhanced aesthetics, greater comfort, and improved oral hygiene. Research indicates that clear aligners are effective in addressing mild to moderate malocclusions, requiring fewer visits and shorter treatment times than traditional fixed appliances. Consequently, it is essential for clinicians to weigh the attributes of these two types of orthodontic devices when determining treatment options.

Keywords: Orthodontic 3D model; tooth movement; Orthodontic fixed appliances; Clear aligners; Geomagic software

1. INTRODUCTION

The process of orthodontic tooth movement is initiated by applying forces to the teeth via particular appliances that orthodontists carefully choose, place, and activate based on the identified malocclusion. The response of the teeth and their supporting tissues to these forces involves a complex biological reaction, resulting in the movement of the teeth through the surrounding structures.

By addressing and minimizing the unknown factors associated with treatment implementation, the variability in clinical outcomes can be reduced. On the other hand, the forces and moments produced during the various phases of orthodontic treatment are subject to controlled variables.

Conventional orthodontic treatment utilizing fixed appliances facilitates tooth movement to treat different kinds of malocclusion by employing fixed components on the surfaces of teeth, including orthodontic bands, brackets, archwires, ligatures, and abutments (Spirito et al. 2023). Consequently, comprehending the biomechanical principles and mechanisms involved in the activation of orthodontic appliances during each phase of tooth movement is crucial for optimizing the effectiveness of orthodontic treatment.

The popularity of aligners in orthodontic treatment has notably increased in recent years, especially among older individuals. This rise can be attributed to their aesthetic advantages, comfort, and the ease of maintaining oral hygiene compared to conventional fixed braces (Madariaga et al. 2020; Stefano et al. 2021). Today, aligners are effectively used to treat various types of malocclusions (Staderini et al. 2020; Dianiskova et al. 2022), thanks to

advancements in abutments, attachments, and aligning materials (Bucci et al. 2019; Stefano et al. 2019). These developments enable the performance of complex movements, including rotation and torque (D'Antò et al. 2022; Stefano et al. 2021).

The introduction of three-dimensional (3D) printing has brought about a significant transformation in dentistry, particularly in the orthodontic correction of malocclusion. While aligners appear to meet the criteria for an ideal orthodontic appliance, certain biomechanical limitations still need to be addressed (Patterson et al. 2021). The predictability of tooth movement is largely contingent upon various factors, including the types of teeth, the desired movements, and the characteristics of the arch, including its structure, thickness, and shape.

Furthermore, studies indicate that aligners provide benefits compared to fixed appliances, particularly in terms of segmented tooth movement and shorter treatment times (Buschang et al. 2014). Conversely, fixed appliances have shown greater efficacy in achieving proper occlusal contacts and managing tooth torque and rotation (Ke et al.2019). Nevertheless, advancements in technology have enabled the treatment of various complex malocclusions using aligners (D'Antò et al. 2023).

According to Smith et al. (2022), in non-extraction patients, only 0.4 of the prescribed movement for each mandibular incisor root tip was clinically achieved with the Invisalign system. Ren et al. (2022) also reported similar findings in a study involving patients who underwent double maxillary extraction of first premolar. Dai et al. (2024) conducted research on patients who had four first premolars extracted and were treated with aligners, revealing that deficits in crown movement resulted in more significant mesial tipping of the maxillary first molars and distal tipping of the maxillary canines than what was anticipated by the clinician's verification software.

The efficiency of tooth movement significantly impacts the establishment of treatment goals, the duration of treatment, and the associated costs. Erroneous predictions may necessitate extended treatment periods, lead to patient dissatisfaction, and increase the risk of relapse. Therefore, it is essential to evaluate the accuracy of tooth movement predictions and the effectiveness of clear aligners in achieving major tooth and root movements when compared to fixed orthodontic treatments.

The results some research indicated that treatment with clear aligners was more effective in terms of duration than treatment with braces. This conclusion is corroborated by Zheng et al. (2017) who found that clear aligners significantly reduced treatment duration compared to braces. It is important to emphasize that the effects are biggest at the biggening of the treatment (first six months).

According to Kravitz et al. (2009), patients experiencing simple malocclusions require an extra 4.8 months of treatment with aligners in comparison to conventional brackets, although the treatment and occlusal results after six months are similar. The study concluded that the device demonstrated the highest precision in achieving lingual displacement, averaging 47.1% accuracy, while egression and mesiodistal tilt were the least precise, with accuracies of 29.6% and 26.9%, respectively. The authors attribute this limitation to the fact that Invisalign® cannot provide a vertical pulling force on teeth.

Also, according to Simon et al.(2014) reported that a distalization of the upper teeth of at least 1.5 mm led to a highly accurate bodily movement of the teeth. The authors also discovered that the accuracy of this movement was increased when it was facilitated by tooth attachment.AlMogbel et al,(2023) noted that if the maximum activation over a two-week period is lowered from 0.5 mm to 0.25 mm or less, it is likely that precision and treatment efficacity will be enhanced

With regard to the importance of this issue from a clinical perspective, and because this issue is underpinned by scientific literature, the aim for this sudy was to compare the movement of the crown and root of the tooth between the two studied groups (traditional braces therapy and aligner therapy) after a predetermined time frame from the beginning of treatment.

2. MATERIAL AND METHOD

To achieve the defined objectives, a clinical trial was conducted at the private dental office specialized for orthodontics "ALJBI ORTODENT" in Tetovo, North Macedonia. Total number of 360 teeth from 30 subjects suffering from primary crowding malocclusion were included in this study. The study population, was aged from 14 to 16 years, include both males and females and categorized into two groups of 15 individuals each, as follows:

- First group: 15 patients, atotal of 180 teeth, from both genders, who will be treated with a fixed appliance, DentaurumRrooth 0.22.

- Second group: 15 patients, a total of 180 teeth, of both genders, who will be treated using an aligner, Biolon 0.75. The following procedures and methodologies were implemented for all participants involved in the study:

- Collection of a comprehensive personal history;
- Clinical examination;
- Evaluation of a digital CT scan of the dental structures;

- Determining the necessity for orthodontic treatment based on the aesthetic criteria of the Index of Orthodontic Treatment Need (IOTN), as outlined by Bruck and Show (1989) and later modified by Richmond (1990) for an objective assessment of orthodontic treatment requirements. This index is also utilized to evaluate patient eligibility for orthodontic treatment within public health contexts (Sharma et al., 2012).
- Development of digital and final models for a virtual treatment plan.
- The post-treatment digital models and the final virtual treatment plan were exported from the software as STL files and subsequently imported into Geomagic Qualify® software for comparison of the final tooth positions. Variations were calculated and analyzed for statistical significance for each tooth in the mesial-distal dimensions.
- Laboratory protocol order: selection and modification of various parameters.
- Digital protocol treatment plan and design: Subsequently, the data from the scanned master model, which is cast in plaster from the patient's impression, will be transformed into an STL file.
- Installation of a fixed orthodontic appliance of the Dentaurum Rroth 0.22 type.
- Installation of an aligner (straightener) of the Biolon 0.75 type.
- Follow-up examinations were conducted in the first month, followed by assessments in the third and sixth months.

Planning, measurements, and simulations are executed on a detailed 3D representation of the teeth, which is initially generated from digital models created by scanning plaster models or through direct intraoral scans. Both intraoral scans and those captured by technical scanners are utilized (refer to Fig. No. 1). Serial 3D models acquired at different time points can be registered and consolidated into a single international coordinate system, facilitating the measurement of tooth mobility. The impact of therapeutic interventions over time has been assessed using various techniques and software tools designed for the digital 3D registration of virtual models and the quantification of tooth movement.

Figure No. 1. Illustrates the analysis of dimensional discrepancies by comparing a scanned object to a reference model. The extent of these deviations is depicted through a color gradient on the right, transitioning from blue to red. A negative deviation, characterized by distal movement, is represented in blue, indicating either an excess or a deficiency of material in the current model. Conversely, a positive deviation, denoting mesial movement, is shown in red. Deviations marked in green are considered negligible or absent, indicating proximity to the nominal tolerance.



Source: authors

3. RESULTS

Table No. 1. and Fig. No.1. show descriptive statistics of the values (limit values) of the mesial-distal direction in 48 teeth at the beginning of the study (To), one month after treatment (T1), three months after treatment (T3), treated

with a fixed appliance (0) and an aligner (1).For F=1.700 and p>0.05 (p=0.193) there is no significant difference between the value of the mesial-distal direction of the teeth at the beginning of the study, one month after treatment, three months after treatment, treated with a fixed appliance and an aligner.

In the Post Hoc Tests / Bonferroni test / analysis of the relation R1*Group; LS Meansfor p>0.05, no significant difference was determined in the displacement of teeth treated with a fixed appliance and aligner, between the values determined at the beginning of the study (T0), one month after treatment (T1), three months after treatment (T3).In Post Hoc Tests / Bonferroni test / analysis of the relation R1*Tooth*Group; LS Means / (Table No. 2.) a significant difference in tooth displacement was registered:

- The value of the mesial-distal direction of displacement during orthodontic treatment with an aligner for tooth 12 after three months of treatment (T3) -0.05 for p<0.001 (p=0.0005) is significantly greater than the initial value of the mesial-distal direction (To) -12.66.

- The value of the mesial-distal direction of displacement during orthodontic treatment with an aligner for tooth 12 after three months of treatment (T3) -0.05 for p<0.001 (p=0.0007) is significantly greater than the value of the mesial-distal direction after 1 month of treatment (T1) -12.41. Among the remaining teeth in the relation R1*Tooth*Group for p>0.05 there is no significant difference in the values of the mesial-distal direction.

Table No. 1. Descriptive statistics of the values (limit values) of the mesial-distal direction in 48 teeth at the beginning of the study (To), one month after treatment (T1), three months after treatment (T3), treated with a fixed appliance (1)

		apphance (anglier (1)			
R1*group; LS Means; Current effect: F(2, 48)=1,7006, p=,19339 Effective hypothesis decomposition							
Cell No	Група	R1	DV_1 Mean	DV_1 Std.Err.	DV_1 -95,00%	DV_1 +95,00%	N
1	0	T0M-D direction	-5,10167	1,759301	-8,73269	-1,47065	24
2	0	T1 M-D direction	-4,73292	1,763317	-8,37222	-1,09361	24
3	0	T3 M-D direction	-5,17167	1,904962	-9,10331	-1,24002	24
4	1	ToM-D direction	-0,41167	1,759301	-4,04269	3,21935	24
5	1	T1 M-D direction	-0,38042	1,763317	-4,01972	3,25889	24
6	1	T3 M-D direction	0,67208	1,904962	-3,25956	4,60373	24

* fixed orthodontic appliance (0), Aligners (1)

Figure No. 2. Values (limit values) of the mesial-distal direction in 48 teeth at the beginning of the study (To), one month after treatment (T1), three months after treatment (T3), treated with a fixed appliance (0) and an aligner (1)



Table No. 2. Post Hoc Tests / Bonferroni test								
Bonferroni test; variable DV_1; Probabilities for Post Hoc Tests Error: Between; Within; Pooled MS = 78,666, df = 25,838								
Cell No	Група	R1	{1} -5,10	{2} -4,73	{3} -5,17	{4} -0,41	{5} -0,38	{6} 0,67
1	0	T0 M-D direction		1,000000	1,000000	1,000000	1,000000	0,492498
2	0	T1 M-D direction	1,000000		1,000000	1,000000	1,000000	0,669071
3	0	T3 M-D direction	1,000000	1,000000		1,000000	1,000000	1,000000
4	1	To M-D direction	1,000000	1,000000	1,000000		1,000000	1,000000
5	1	T1 M-D direction	1,000000	1,000000	1,000000	1,000000		1,000000
6	1	T3 M-D direction	0,492498	0,669071	1,000000	1,000000	1,000000	

* Fixed orthodontic appliance (0), Aligners (1)

4. DISCUSSION

Orthodontic tooth movement is achieved by applying forces to the teeth through specific appliances that orthodontists select, position, and activate according to the malocclusion type. The teeth and their surrounding supportive tissues respond to these forces with a complex biological reaction, leading to the movement of the teeth through the supporting structures. By reducing the unknown factors involved in treatment implementation, the variability of clinical outcomes can be minimized. In contrast, the forces and moments generated during different phases of orthodontic treatment are governed by controlled variables.

Most fixed appliances are designed to deliver continuous forces. Continuous force is defined as a force that is sustained within certain intervals, ensuring that its intensity does not drop below the threshold necessary to stimulate cellular activity (including apposition and resorption) during orthodontic treatment. These forces are gentle, enabling consistent and uniform movement of the teeth over prolonged periods.

Aligners have gained popularity not only for their aesthetic appeal but also for their ability to enhance oral hygiene compared to traditional fixed orthodontic appliances. Nevertheless, from a biomechanical perspective, the two treatment modalities are not yet equivalent (D'Alessandro et al., 2020). Aligner therapy, which involves custom-made and removable appliances, is increasingly adopted in clinical settings as a more aesthetically pleasing and comfortable alternative to multi-attachment systems (Macri et al., 2023). Over time, there has been a shift towards more aesthetically pleasing orthodontic appliances, driven by technological advancements and a growing number of adults seeking orthodontic care.

Borda et al. conducted a study in 2020 to compare the efficacy and efficiency of clear aligners with fixed appliances in treating mild malocclusions in adolescents. The research analyzed retrospective data from a private practice, which included 26 patients in each treatment group, either receiving Invisalign or Damon braces. The findings revealed that the aligner group had significantly fewer discrepancies from the ideal treatment outcome (CRE: 30.1 vs. 37.0; P < .01). Furthermore, aligner patients attended fewer appointments (13.7 compared to 19.3; P < .0001), had a reduced number of emergency visits (0.8 vs. 3.6; P < .0001), and completed their treatment in a shorter time frame (16.9 months vs. 23.4 months; P < .0001). Thus, while clear aligners were found to be equally effective as fixed appliances for mild malocclusions, they offered enhanced efficiency in the treatment process.

According to the results from this study, there is no significant difference between the value of the mesial-distal direction of the teeth at the beginning of the study, one month after treatment, three months after treatment treated with a fixed appliance and an aligners. This findings are similar to the data presented by numerous studies did not found the statistically significant difference between two appliances (Li et al, 2015; Hennessy et al, 2016; Gu et al, 2017; Laneti et al, 2018). Other studies verified that clear aligners could not treat malocclusion as well as braces. (Djeu et al, 2005; Kuncio et al, 2007; Pavoni et al, 2011; Grünheid et al, 2016)

Nonetheless, additional studies are necessary to fully assess their effects on oral health, particularly in more complicated cases, and to analyze the clinical efficacy of various aligner brands.

5. CONCLUSIONS

Clear aligner therapy marks a notable progression in orthodontic care, providing benefits over conventional braces, including enhanced aesthetics, greater comfort, and improved oral hygiene. Research indicates that clear aligners are effective in addressing mild to moderate malocclusions, requiring fewer visits and shorter treatment times than

traditional fixed appliances. Consequently, it is essential for clinicians to weigh the attributes of these two types of orthodontic devices when determining treatment options.

BIBLIOGRAPHY

AlMogbel, A. (2023). Clear Aligner Therapy: Up to date review article. *Journal of orthodontic science*, 12(1), 37.

- Borda, A. F., Garfinkle, J. S., Covell Jr, D. A., Wang, M., Doyle, L., Sedgley, C. M. (2020). Outcome assessment of orthodontic clear aligner vs fixed appliance treatment in a teenage population with mild malocclusions. *The Angle Orthodontist*, *90*(4), 485-490.
- Bucci R., Rongo R., Levatè C., Michelotti A., Barone S., Razionale A.V., D'Antò V.(2019). Thickness of Orthodontic Clear Aligners after Thermoforming and after 10 Days of Intraoral Exposure: A Prospective Clinical Study. Prog Orthod 9;20(1):36.
- Buschang, P.H. Shaw, S.G., Ross, M. Crosby, D., Campbell, P.M. (2014) Comparative Time Efficiency of Aligner Therapy and Conventional Edgewise Braces. Angle Orthod., 84, 391–396.
- D'Alessandro Ch A., D'Anto V., Razionale V.A., Alessandri-Bonetti G., (2020). Integrating CBCT and Virtual Models for Root Movement with Clear Aligners. <u>www.jco-online.com</u>
- D'Antò V., Bucci R., De Simone V., Ghislanzoni H L., Michelotti A., Rongo R.(2022). Evaluation of Tooth Movement Accuracy with Aligners: A Prospective Study. Materials (Basel) 4;15(7):2646.
- D'Antò, V.; Valletta, R.; De Simone, V.; Pisano, M.; Stefano M., (2023) Clear Aligners Treatment of Class III Subdivision with an Extraction of a Lower Bicuspid. Int J Environ Res Public Health. 20(4): 3550.
- Dai, F., Sang, Y., Zeng, J., Wang, H., Pan, Y., Zhao, J., Xu, T., Shu, G. (2024). How accurate is predicted root movement achieved in four first-premolar extraction cases with Invisalign?. *Orthodontics & craniofacial research*, 27(6), 985–995. <u>https://doi.org/10.1111/ocr.12842</u>
- Dianiskova S., Rongo R., Buono R., Franchi L., Michelotti A., D'Antò V.(2022). Treatment of mild Class II malocclusion in growing patients with clear aligners versus fixed multibracket therapy: A retrospective study. OrthodCraniofac Res 25(1):96-102.
- Djeu, G., Shelton, C., Maganzini, A. (2005). Outcome assessment of Invisalign and traditional orthodontic treatment compared with the American Board of Orthodontics objective grading system. *American journal of orthodontics and dentofacial orthopedics*, 128(3), 292-298.
- Grünheid, T., Gaalaas, S., Hamdan, H., Larson, B. E. (2016). Effect of clear aligner therapy on the buccolingual inclination of mandibular canines and the intercanine distance. *The Angle Orthodontist*, 86(1), 10-16.
- Gu, J., Tang, J. S., Skulski, B., Fields Jr, H. W., Beck, F. M., Firestone, A. R., ... Deguchi, T. (2017). Evaluation of Invisalign treatment effectiveness and efficiency compared with conventional fixed appliances using the Peer Assessment Rating index. American Journal of Orthodontics and Dentofacial Orthopedics, 151(2), 259-266.
- Hennessy, J., Garvey, T., Al-Awadhi, E. A. (2016). A randomized clinical trial comparing mandibular incisor proclination produced by fixed labial appliances and clear aligners. *The Angle Orthodontist*, *86*(5),706-712.
- Ke, Y. Zhu, Y. Zhu, M. (2019). A Comparison of Treatment Effectiveness between Clear Aligner and Fixed Appliance Therapies. BMC Oral Health 23;19(1):24.
- Kravitz, N. D., Kusnoto, B., BeGole, E., Obrez, A., Agran, B. (2009). How well does Invisalign work? A prospective clinical study evaluating the efficacy of tooth movement with Invisalign. *American Journal of Orthodontics and Dentofacial Orthopedics*, 135(1), 27-35.
- Kuncio, D., Maganzini, A., Shelton, C., Freeman, K. (2007). Invisalign and traditional orthodontic treatment postretention outcomes compared using the American Board of Orthodontics objective grading system. *The Angle Orthodontist*, 77(5), 864-869.
- Lanteri, V., Farronato, G., Lanteri, C., Caravita, R., Cossellu, G. (2018). The efficacy of orthodontic treatments for anterior crowding with Invisalign compared with fixed appliances using the Peer Assessment Rating Index. *Quintessence International*, 49(7).
- Li, W., Wang, S., Zhang, Y. (2015). The effectiveness of the Invisalign appliance in extraction cases using the the ABO model grading system: a multicenter randomized controlled trial. *International journal of clinical and experimental medicine*, *8*(5), 8276.
- Macrì, M., Medori, S., Varvara, G., Festa, F. (2023). A digital 3D retrospective study evaluating the efficacy of root control during orthodontic treatment with clear aligners. *Applied Sciences*, 13(3), 1540.
- Madariaga A.C.P., Bucci R., Rongo R., Simeon V., D'Antò V., Valletta R.(2020). Impact of Fixed Orthodontic Appliance and Clear Aligners on the Periodontal Health: A Prospective Clinical Study. Dent J (Basel) 2;8(1):4.
- Patterson D. B., Foley F. P., Ueno H., Mason A. Sh., Schneider P P., Kim B K. (2021). Class II malocclusion correction with Invisalign: Is it possible? Am J Orthod Dentofacial Orthop 159(1):e41-e48.

- Pavoni, C., Lione, R., Laganà, G., Cozza, P. (2011). Self-ligating versus Invisalign: analysis of dento-alveolar effects. *Annali di stomatologia*, 2(1-2), 23.
- Ren, L., Liu, L., Wu, Z., Shan, D., Pu, L., Gao, Y., ... Lai, W. (2022). The predictability of orthodontic tooth movements through clear aligner among first-premolar extraction patients: a multivariate analysis. *Progress in Orthodontics*, 23(1), 52.
- Simon, M., Keilig, L., Schwarze, J., Jung, B. A., Bourauel, C. (2014). Treatment outcome and efficacy of an aligner technique–regarding incisor torque, premolar derotation and molar distalization. *BMC oral health*, *14*, 1-7.
- Smith, J. M., Weir, T., Kaang, A., Farella, M. (2022). Predictability of lower incisor tip using clear aligner therapy. *Progress in orthodontics*, 23(1), 37.
- Spirito F Di., D'Ambrosio F., Cannatà D., D'Antò V., Giordano F. and Stefano M., (2023). Impact of Clear Aligners versus Fixed Appliances on Periodontal Status of Patients Undergoing Orthodontic Treatment: A Systematic Review of Systematic Reviews. Healthcare .; 11(9): 1340.
- Staderini E., Patini R., Meuli S., Camodeca A., Guglielmi F., Gallenzi P.(2020). Indication of clear aligners in the early treatment of anterior crossbite: A case series. Dental Press J Orthod 25(4):33-43.
- Stefano M., Amato A. Faccioni P., Landolo A., Amato M., Rongo R., (2021). The perception of COVID-19 among Italian dental patients: An orthodontic point of view. Prog Orthod 7;22(1):11.
- Stefano M., Martini M., Bordegoni M., Razionale A.V.(2021). Predictability of Root Movements Using Virtual Root Setup in a Patient with Periodontal Disease Treated with Clear Aligners. Open Dent. J. 15:605– 611.
- Stefano M., Rongo R., Bucci R., RazionaleV A., Valletta R., D'Antò V., (2019). In vitro cytotoxicity of different thermoplastic materials for clear aligners. Angle Orthod. ;89:942–945.
- Zheng, M., Liu, R., Ni, Z., Yu, Z. (2017). Efficiency, effectiveness and treatment stability of clear aligners: A systematic review and meta-analysis. *Orthodontics & craniofacial research*, 20(3), 127-133.