APPLICATIONS OF DIGITAL TECHNOLOGY IN DATA TRANSFER FROM THE DENTAL OFFICE TO THE DENTAL LAB

Iulia-Roxana Marinescu[1], Horia Octavian Manolea[2] , Alexandru Andrei Iliescu[1], Monica Scrieciu[3], Willi Uriciuc[4], Adrian Marcel Popescu[5]

[1] University of Medicine and Pharmacy of Craiova, Romania, Faculty of Dentistry, Department of Oral Rehabilitation
[2] University of Medicine and Pharmacy of Craiova, Romania, Faculty of Dental Medicine, Department of Dental Materials
[3] University of Medicine and Pharmacy of Craiova, Romania, Faculty of Dental Medicine, Department of Dental Prosthetics
[4] Iuliu Haţieganu University of Medicine and Pharmacy Cluj-Napoca, Faculty of Dentistry, Department of Oral Rehabilitation
[5] University of Medicine and Pharmacy of Craiova, Romania, Faculty of Dentistry, PhD student

Corresponding author: *e-mail: horia.manolea@umfcv.ro*

ABSTRACT

Nowadays, digital technologies represent an essential tool for dentists and dental technicians, and the backbone of the communication between them. **Aim of the study** is to analyze the application of digital technologies in a common dental office and in transferring information to the dental lab. **Materials and methods.** The retrospective study included patients who presented for treatment to the dentist, in a 12 months period of time. Searched databases included dental charts, radiologic and imagistic data (OPG, CBCT), clinical photos and digital dental impressions. A comparison was made between the used digital tools as frequency. **Results:** 580 patients were included, 275 men and 305 women, aged between 19 and 82. Digital technologies used in the dental office in the studied period were: OPG (100%), CBCT examinations (25,34%), digital photographic exams (38,10%), intraoral scanning (24,13%), digital intraoral impressions (19,65%). **Conclusions:** All patients who attended the dental office during the study period received an OPG examination, while significant fewer patients were investigated using other digital technologies. For an easier, faster and complete data transfer between dental office and dental lab, digital evaluation is mandatory.

KEY WORDS: digital dentistry, optical impression, intraoral scan, dental laboratory, oral rehabilitation.

INTRODUCTION

During the last years, digital technologies have changed the clinical approach in medicine and in dentistry and new restorative materials and innovative techniques gave a boost towards full digital workflows [1,2]. Digital tools are changing and enhancing communication, data acquisition and sharing, design and production, with undeniable advantages in our working routine [3].

Dentistry digital workflow acts in different fields of application, from treatment planning/ designing to prototyping steps, from implant surgery procedures [4,5] to the fabrication of customized prostheses and devices produced by computer-aided design/computer-aided manufacturing (CAD/CAM) additive and subtractive technologies [6]. Clinical procedures and laboratory technologies move towards workflows oriented in an increasingly digital way [7,8].

DOI : 10.6261/RJOR.2024.3.16.5

Other digital technologies frequently used in the dental office are orthopantomography (OPG) and cone beam computer tomography (CBCT), and without them, treatment planning and oral rehabilitation with dental implants would not be possible [9].

Digital technologies implementation in current dental practice begins with digital photography, a mandatory complementary exam for any clinical case documentation, a standard procedure [10], simple, fast, for the patient's education and for follow up during dental treatments, offering multiple benefits for both patients and dentists [11].

One of the most current topics in dentistry is the use of intraoral scanners, which, together with CAD/CAM technologies, enables an easier treatment plan, data storage and reduced treatment time [12,13,14].

Clinical studies concluded that conventional impressions were the most unpleasant experiences in the dental office, from the patients' point of view, during fixed [14,15], removable [15], and implant prosthodontics [16,17].

Intraoral scanning (IOS) is an alternative to conventional impressions, allowing previsualization of the area of interest in three dimensions, reduced working time, and improved patient-reported outcomes [18, 19,20,21].

Digital data obtained with IOS, combined with computer-aided design (CAD) and computer-aided manufacturing (CAM) allows a completely digital prosthetic workflow, which has been extensively investigated in the context of fixed prosthodontics [22] and implant dentistry [23]. The aim of the study is to analyze the application of digital technologies in the dental office and the information transferring from the dental office to the dental lab.

MATERIALS AND METHODS

The retrospective study included patients who presented to a dental clinic, for treatment, in a 12 months period of time, from April 2022 to March 2023. Searched databases included dental charts, radiologic and imagistic data (OPG, CBCT), clinical photos and digital dental impressions took in this period. Dental office has a regulation that imposes a written informed consent for all patients, for all types of investigations and treatment, but also for permission to use their data for research. The study was approved by the Ethics Committee of University of Medicine and Pharmacy Craiova, no. 197/24.11.2021.

Inclusion criteria for patients: adult with age over 19 years presented for evaluation and treatment in the 12 months period, between April 2022 and March 2023.

Exclusion criteria for patients: children until the age of 18.

The procedure for transferring data to the dental lab included: the photographic exam and the intraoral scanning, together with imagistic investigations (OPG, CBCT) were sent to the dental laboratory, as an important stage of the digital workflow, to design different prosthetic restorations, by CAD-CAM process. OPG and CBCT were performed with captured with the Smart 3D LargeV X-ray device (exposure parameters 100KV/ 6mA) (Large View, Beijing, China). The photos were taken with the Nikon D750 camera (Nikon AF micro 60 mm lenses) (Nikon Corporation, Japan) and with Xiaomi 13 smartphone (Xiaomi Communication Co, Beijing, China). The

DOI : 10.6261/RJOR.2024.3.16.5

optical impression was taken with the Medit i700 intraoral scanner (Medit, Seul, South Coreea), following the scanner usage protocol and the scanning protocol. The acquired data, as STL files, were sent to the dental laboratory by e-mail. Communication with the dental lab was made by e-mail, and other means of communication, like WhatsApp. Statistical analysis was performed with Microsoft Excel and the z score test was used, for two population proportions. P values were considered significant if <0.001.

RESULTS AND DISCUSSIONS

The study included 580 patients, 275 men and 305 women, aged between 19 and 82 (mean age 67±12 years). In the 12 months period of study, digital technologies used in the dental office were OPG, CBCT, digital photography and intraoral scanning. Number of procedures done in this period were: 580 OPG, 147 CBCT examinations, 221 digital photographic exams, 140 intraoral scanning, 114 digital impressions (Table 1).

Table 1. Digital technologies used for data transfer, from the dental office to the dental lab.

Patients	OPG N (%)	CBCT N (%)	Photographic exam N (%)	Intraoral scan N (%)	Intraoral digital impression N (%)	Total N (%)
Men	275 (47.41)	66 (11.37)	94 (16.21)	72 (12.41)	61 (10.51)	275 (47.41)
Women	305 (52.58)	81 (13.97)	127 (21.89)	68 (11.72)	53 (9.14)	305 (52.58)
Age 19-40	214 (36.89)	59 (10.17)	112 (19.31)	88 (15.17)	67 (11.55)	214 (36.89)
Age 41-82	366 (63.1)	88 (15.17)	109 (18.79)	52 (8.96)	47 (8.10)	366 (63.1)
Total	580 (100)	147 (2534)*	221 (38,10)*	140 (24,13)*	114 (19,65)*	580 (100)

z test *p< 0.0001

The results showed that, compared to the OPG exam, all the other digital exams were performed in significant statistic lower cases.

The only digital technology used for all the patients is OPG. Since the covid pandemic, the radiological assessment with RIO has been replaced with OPG, which has become a complementary routine examination, for all patients presented for diagnosis and treatment in the dental office. The following technologies, in terms of frequency, used in the office were intraoral scans, digital photos and CBCT. The other technologies were used only for cases where digital workflow was implemented for complex oral rehabilitation.

With all available digital tools, easy and accessible communication between dentists and dental technicians must not be problematic. By exploiting modern technologies in dentistry, dentists can improve productivity, quality and communication with the dental labs [24].

The use of modern and efficient means and the acquisition of communication skills are

DOI : 10.6261/RJOR.2024.3.16.5

important not only in the relationship with dental technicians, but also in relation with the patients, as shown by a recent study [25], which stated that verbal and visual communication methods like PowerPoint presentation for patient information, before and after photos of other patients, intraoral mock-up and digital computer-imaging simulation positively influences patient-dentist relationship, information retention, treatment acceptance, quality of care or treatment outcome.

Photographic exam, CBCT planning of the implant-prosthetic treatment with the SmartV Pro software and intraoral scanning with Medit i700 scanner have been used and all these data were corroborated and sent to the laboratory, ensuring a digital and modern workflow, to make the requested prosthetic restorations.

The first stage of digital workflow includes clinical examination and OPG assessment. Depending on every patient's specific treatment needs, in some cases, CBCT examination is further needed. Studies [24,26] show that nearly half of the respondents use digital photography, to enhance the provided written instruction, which they transmit via different online sharing platforms (Drop Box, WhatsApp, Email). The photographic exam is performed especially for patients undergoing through a prosthetic rehabilitation, because the photos help the documentation of the clinical case and they are a powerful communication method to the dental technician, who often can't have a direct contact with the patient, helping him to perform the most appropriate prosthetic rehabilitation, considering the shape, the color and the restauration's integration into the patient's dental-somatic-facial harmony.

The intraoral scanner is a medical device consisting of a manually controlled camera (hardware), a computer and software, the objective of the intraoral scan being the precise registration of the three-dimensional geometry of the soft and hard intraoral tissues [27]. An optical impression made with the intraoral scanner involves optical measurements of the shape and surface of the target teeth or soft tissues directly in the patient's oral cavity, thus obtaining 3D digital models with information on the shape and surface of the scanned teeth, adjacent soft tissues, opposing teeth and occlusion status. All information captured by the intraoral scanner is converted into digital information/ data reflecting the intraoral situation in the form of virtual models. This information is then transferred as STL (stereolithography/ STL) data to be used for design in CAD software and component materials in CAM software [28].

The scanning protocol begins by creating a folder, where the patient's identification data, the type, the material and the color of the future prosthetic restauration will be specified.

After completing these steps, the intraoral scanning is performed. The mandible, maxilla and occlusion (left\right) will be scanned, following the scanning protocol.

The scan will start from the occlusal surface of the last mandibular molar and will continue from posterior to anterior, up to the incisors. For the incisors, the lingual surfaces will initially be scanned up to the incisal edges, then the buccal surfaces will be scanned with a tilting movement.

DOI : 10.6261/RJOR.2024.3.16.5

After finalizing the process in the anterior area, the scan of the occlusal faces will continue up to the last molar on the arch, then, a tilting movement of the scanner will be made towards the lingual surface of the tooth that must be scanned together with the gum. From this point, the scan will continue with the lingual surfaces, starting from the last molar on one half-arch to the one on the opposite half-arch. After scanning the lingual surfaces, starting from the level of the occlusal surface of the last molar, a tilting movement will be made towards the buccal surface of the molar, which will be scanned together with the adjacent gingival tissue. From this point, the scan will continue up to the last molar on the opposite half-arch, finalizing the lower arch scan. The same steps will be performed at the upper jaw [29].

The distance between the end of the scanner and the scanned surfaces is an important factor influencing the data accuracy. A too short distance (5mm), when the light beam emitted by the scanner becomes oversaturated, or a too long distance (over 15 mm), when the sensor is not able to successfully record all the light reflected from the scanned surfaces, have a negative impact. The optimal distance between the tip of the scanner and the scanned surfaces is 10 mm [30].

To perform the occlusion scan, the patient will have the occlusal plane parallel to the floor. The mandible and maxilla scans will be checked for errors, then the occlusion scan option will be selected. The tip of the scanner will be positioned in the middle of the deepest posterior area of the jaws. After we have correctly positioned the scanner in the patient's oral cavity, we will start scanning the occlusion using a wavy scanning technique, from posterior to the anterior area, until we have scanned 3-4 teeth, on both right and left sides. When the system considers that sufficient 3D data has been scanned, the automatic alignment process will begin, which will finalize the intraoral scanning procedure [29].

From the scan, STL files are generated to Exocad Dental software and exported to the dental laboratory, to design the future prosthetic restorations [31].

For the implant-prosthetic treatment, in cases with partial edentulism, OPG, CBCT, and intraoral scanning are used to obtain data. After the clinical examination of the patient and of the bone supply on CBCT, the implant-prosthetic treatment planning is carried out with the radiological software, deciding to insert four dental implants, on 1.5, 1.7, 4.5, 4.7 positions. The prosthetic stage started with the implants uncover, the healing caps application and the intra-oral scan. Four scan-bodies have been used, to transmit the implants position, with the STL files to the dental laboratory, to create two antagonist, porcelain fused to metal prosthetic restorations. The dental lab sent the digital design of the restorations to the dental office, before starting their technical execution. After the implant-supported prosthetic restorations (PR) have been placed in the patient’s oral cavity, a new radiological check was made, to assess the PR’s fit and, the bone integration of the two implants that have been inserted meanwhile, in the upper right quadrant. (Fig. 1)

DOI : 10.6261/RJOR.2024.3.16.5

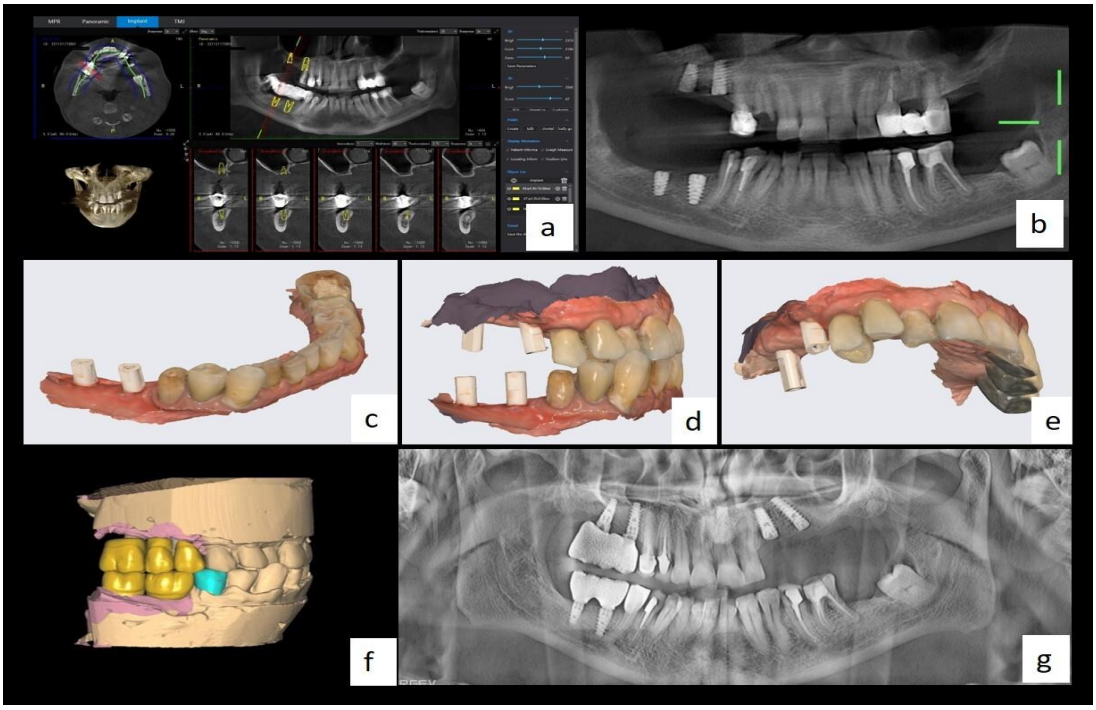

Figure 1. a) The implant-prosthetic treatment planification, using SmartV Pro software. b) Radiological assessment of the implants bone integration, 8 months after the surgical stage. c), d), e) Intraoral scanning of the upper, lower jaw and of the occlusion. f) Restorations' digital design. g) OPG assessing implant-supported prosthetic restorations and the bone integration of the upper right quadrant dental implants.

Digital communication allows dentists and technicians the opportunity to make decisions quickly and concisely before, during, and after treatment [32]. The dental office uses an information transmission to the dental laboratory for a surgical guide design, to be able to perform a precise and safe insertion of two implants, for the upper left missing bicuspids. With the help of the MEDIT Scan for Clinics software and the Medit i700 intraoral scanner, the scanning of the mandibular, maxillary arch and of the occlusion was performed and recorded. For the surgical guide, in addition to the intraoral scan, it was also necessary to perform a CBCT of the second quadrant, to highlight the bone support in the missing teeth area. The digital file of the intraoral scanning together with the CBCT, have been exported to the dental laboratory. With the ExoPlan software, the future surgical guide was designed and used for a more precise insertion of the two implants, replacing the 2.4 and 2.5 missing teeth. (Fig. 2)

DOI : 10.6261/RJOR.2024.3.16.5

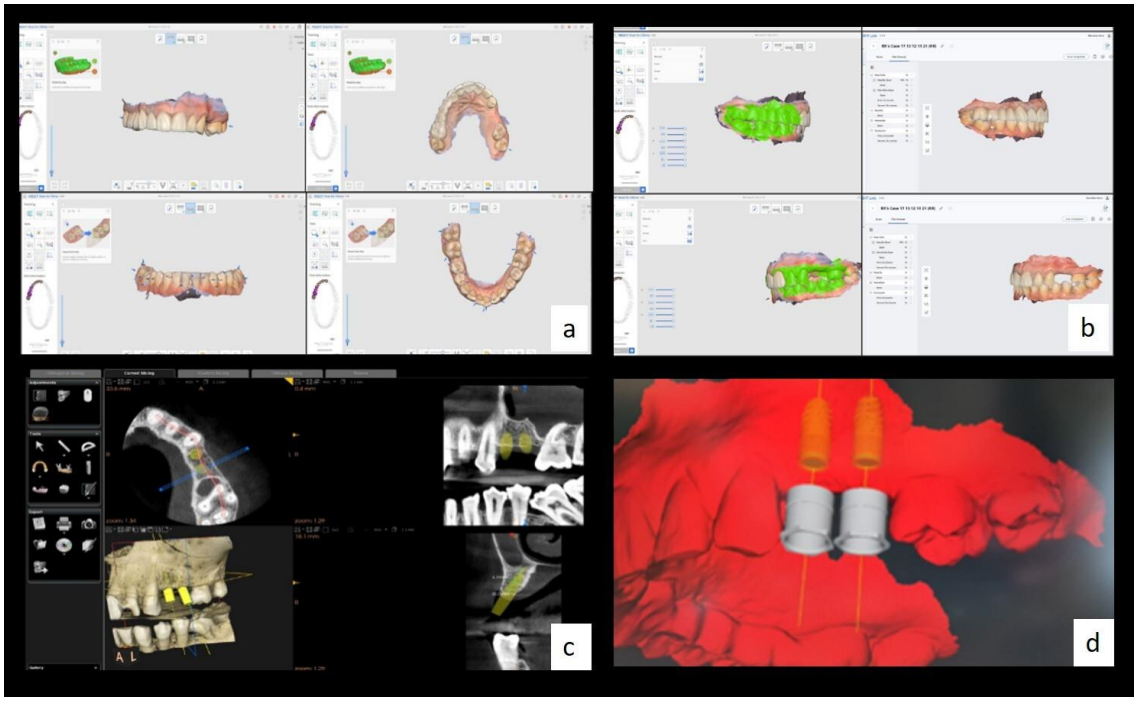

Figure 2. a) The intraoral scan viewed in the MEDIT Link software menu: the maxillary arch (anterior view, occlusal) and the mandibular arch (anterior view, occlusal). b) The intraoral scan with the intermaxillary relations recordings, in maximum intercuspation. c) CBCT aspect of the interest area (2.4 and 2.5 missing teeth) and digital planning of the implants position. d) Determining the final position of the implants and positioning the sleeves of the future surgical guide with ExoPlan software.

More than 85% of the practitioners in UK [33] and Morocco [24] share the same point of view and are convinced that digitalization of dentistry is a mean to optimize communication. According to the same study [24], 13.8% of CAD/CAM users chose it to improve the relationship with the laboratory technicians.

Often patients come to the dental office complaining about food retention. For a situation of food retention between the first and second lower right molars, with clinical signs of gingival trauma due to incorrect adaptation of the class two composite fillings, it has been decided to replace the 4.6 distal filling with a zirconia onlay, that will restore the interproximal contact point with the second molar, avoiding food retention. An intraoral scan was performed, after the teeth preparation (Fig. 3).

DOI : 10.6261/RJOR.2024.3.16.5

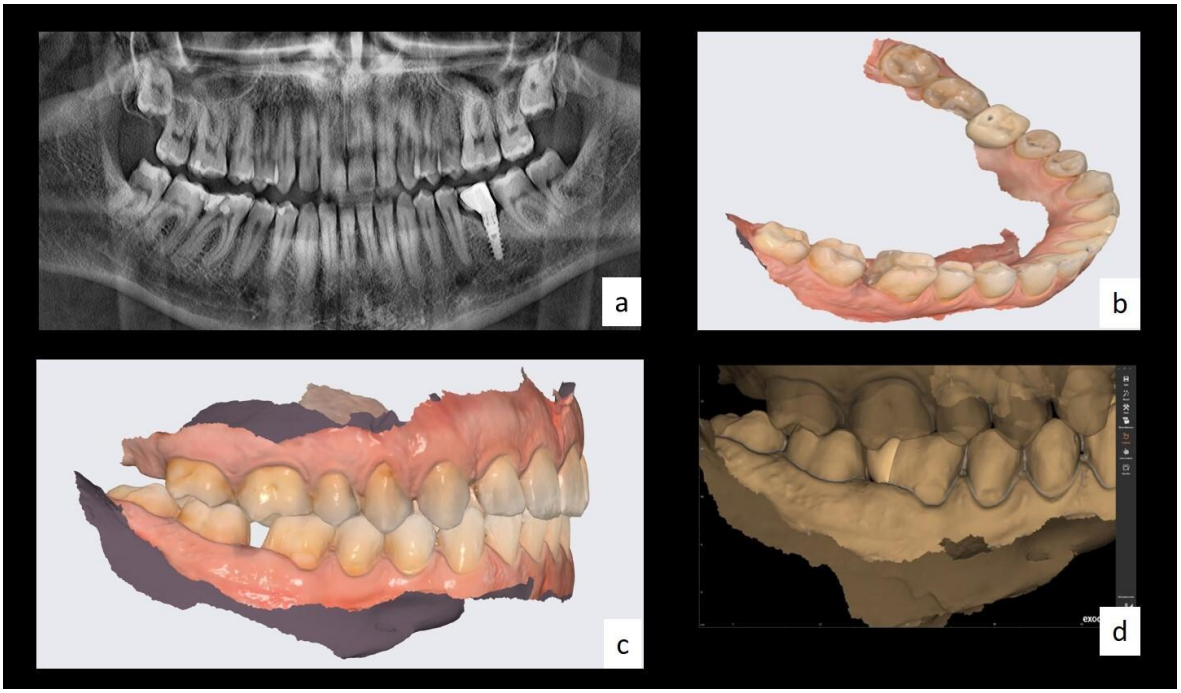

Figure 3. a) OPG showing the poor adaptation of the two proximal fillings on 4.6 and 4.7, which do not correctly restore the interproximal contact point. b) Intraoral scan after the 4.6 distal preparation. c) Dental occlusion scan. d) Aspect of the digital design of the future partial crown (onlay).

In some situations, patients are recommended to wear provisional dental bridges for periodontal stabilization of teeth undergoing specific periodontal treatment. An intraoral scan of the provisional dental bridge was performed, with the purpose of transmitting to the dental lab data about the aspect, shape and adaptation of this PR, to which the patient declared to be satisfied of and wanted to be transferred to the long-term restoration, porcelain fused to metal dental bridge. (Fig. 4)

DOI : 10.6261/RJOR.2024.3.16.5

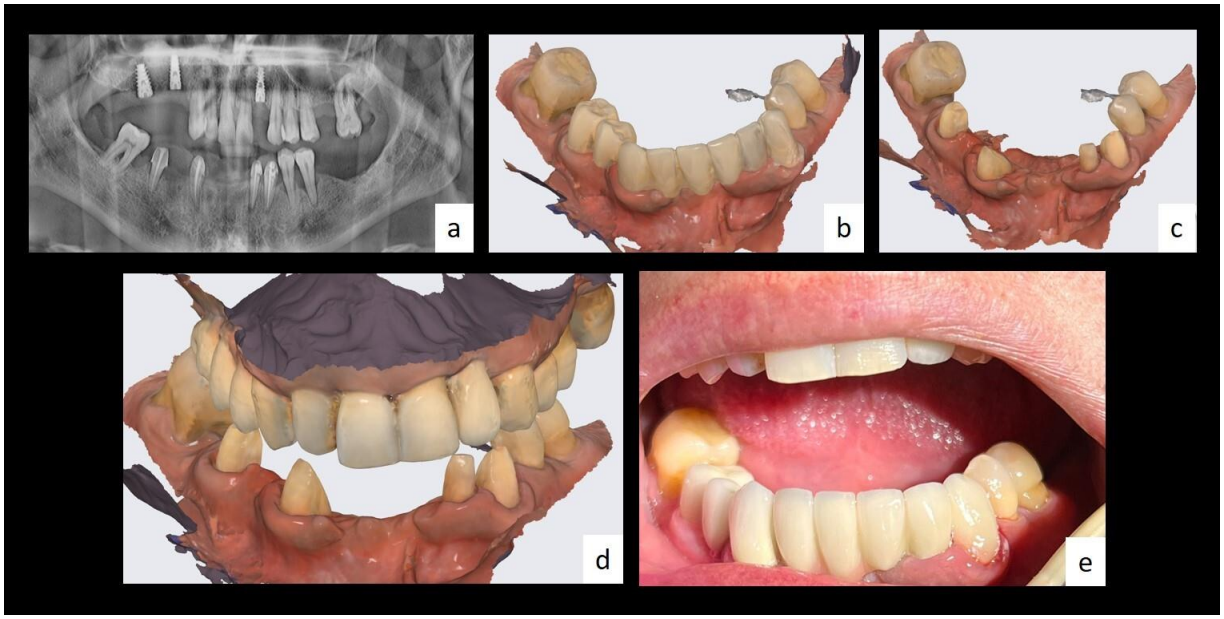

Fig. 4 OPG after provisional restauration remove. b) Intraoral scan of the provisional anterior lower dental bridge. c) Prepared teeth scanning. d) Scan of the intermaxillary relations. e) Final anterior porcelain fused to metal restoration.

A study [34] on the prevalence of and factors associated with total edentulism in the elderly Brazilian population, where more 40000 subjects were included, found that 32% had completely lost their teeth. Situations like this, with total or sub-total edentulism, when the patient was wearing removable dentures may be treated with fixed implant supported oral rehabilitation. The lower jaw rehabilitation started with CBCT implants insertion planification, which has been made on the initial imagistic examination, before the maxillary implants insertion. The upper jaw was restored prior to the lower jaw. The maxillary implant supported bridge was performed in classic manner, with conventional impressions. Four months after the mandibular surgical stage, an OPG was made, to assess the bone integration and it was decided to prosthetic restore with implants supported monolithic zirconia bridge, except for the last implant in the 3rd quadrant, which was not bone integrated. (Fig. 5)

DOI : 10.6261/RJOR.2024.3.16.5

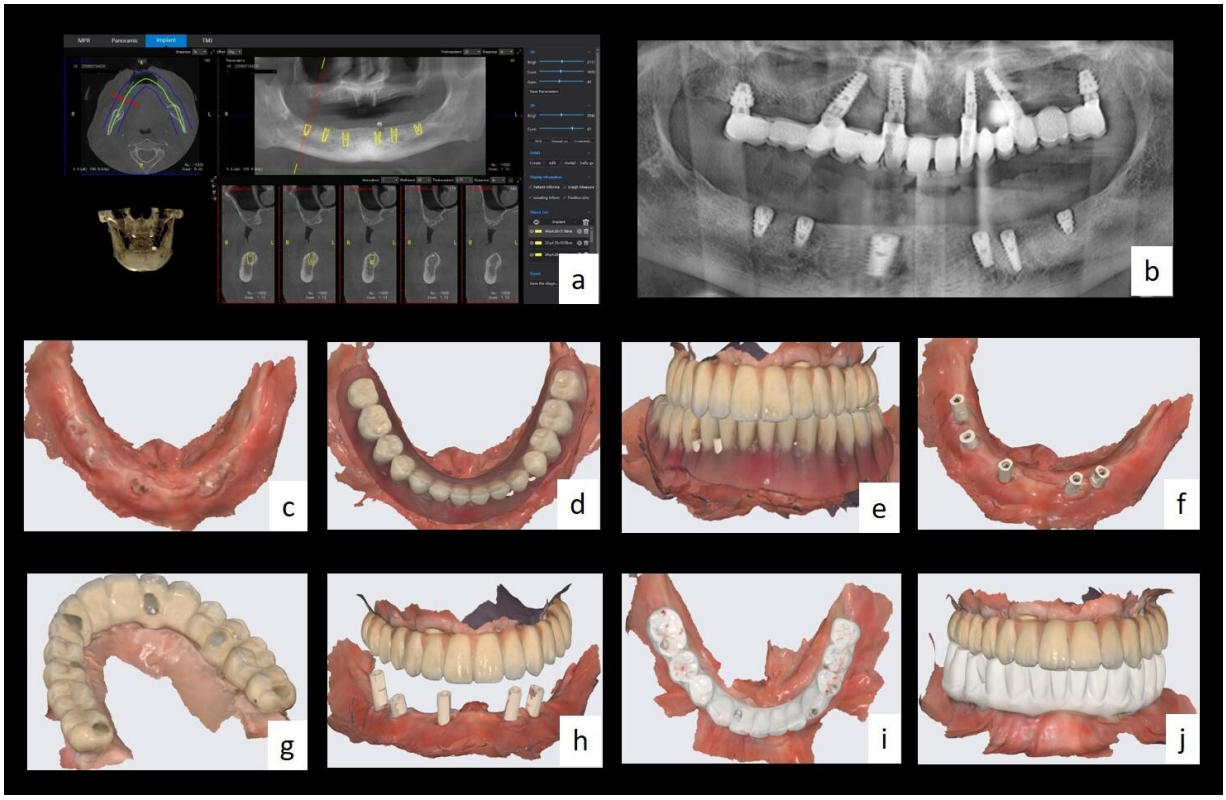

Figure 5. a) CBCT planification of the mandibular implants positioning. b) OPG made to assess the mandibular implants bone integration. c) Edentulous mandible scan. d), e) Lower removable denture scan to send to the dental lab, to keep the data about the teeth (shape, size) and occlusion. f) Scan bodies. g) Maxillary implant-supported porcelain fused to metal restoration scan. h) Intermaxillary relation (centric occlusion). i) Try-in intraoral scan showing articulating paper marks. j) Intermaxillary relation.

From the 140 intraoral scans included in this study, those for orthodontic pathology, that have been treated with physiognomic dental aligners, were sent to the dental lab, via STL files, to correct the teeth malposition with crowding. (Fig 6)

DOI : 10.6261/RJOR.2024.3.16.5

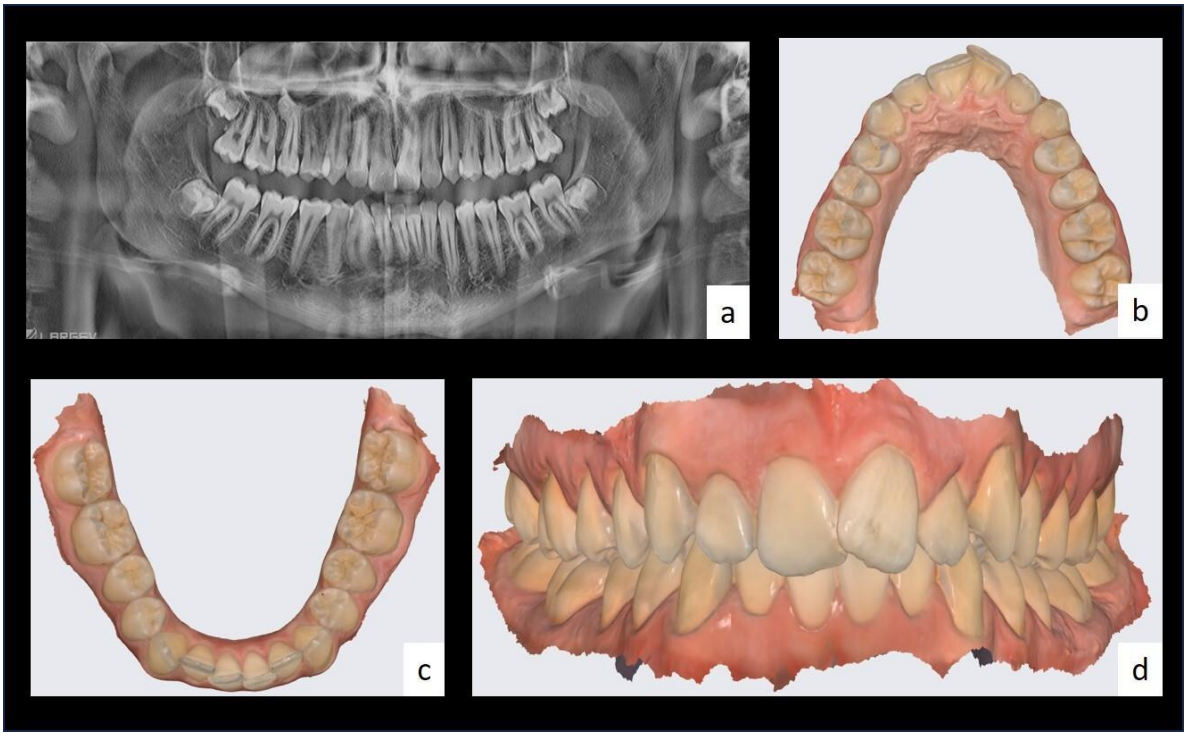

Figure 6. a) OPG showing the orthodontic pathology, Teeth malposition with crowding. b), c) Intraoral scan of the maxillary and mandibular occlusal surfaces. d) Occlusion scan.

In recent years, digital technologies have become widely used in dental practice, resulting in a consistent evolution and transformation of clinical workflows. The digitalization process radically changed the dentistry world, becoming part of it [35].

An essential step in prosthetic restoration is taking the impression. Since 1980, when the first intraoral scanner (IOS) was made, this technology developed continuously and, in 1987, the first intraoral scanner (IOS) was introduced on the dental market [36]. The digital workflow was implemented earlier in the dental laboratory setting than in the clinical one, through an indirect digitalization process. In particular, the conventional impression performed by the dentist was supposed to be casted in the laboratory to obtain a physical model, then digitalized using an optical scanner.

The results of a 2021 survey [24] showed that even if the optical impression enables more precise and instantaneous communication with dental technicians by transferring the scanned data to the laboratory, through a web portal, however, this procedure focused only on small gap extent [37] and the use of conventional impression techniques was by far the majority (97.1%), with only (2.7%) of practitioners associating the two techniques.

A study [35] on the accuracy of different intra-oral scanners concluded that Medit i700 recorded the best results in terms of trueness and precision and no recording technique was found to be the best. Considering the experience of the operators, scanning strategies are not operative sensitive in terms of accuracy. However, they are in terms of time spent in scanning.

To capture the correct position of the implant, it is necessary to use a specific

DOI : 10.6261/RJOR.2024.3.16.5

transfer device called intraoral scan body, because edentulous areas can be difficult to scan, due to the absence of anatomical landmarks. Multiple factors may influence intraoral scanning for implant supported restorations, such as: scanning technology and the condition of the transfer devices, the oral cavity temperature and the illumination of the areas to be scanned, the doctor's experience, patient's movements during intraoral scanning, limited opening of the mouth, the presence of an enlarged tongue, the material the transfer device is made of, the transfer device light reflection [38].

CONCLUSIONS

The only digital technology used for all the patients is OPG. The other technologies were used only for cases where digital workflow was implemented for oral rehabilitation.

The results of the study show that digital technologies are necessary for an easier, faster and complete data transfer between dental office and dental lab.

A lot of dental services could not be performed without these technologies, like oral rehabilitations with dental implants, new types of zirconia restorations, orthodontic treatment with physiognomic dental aligners etc.

The era of the digital technologies arrived and nowadays is in full expansion. Even if dental offices were quite reluctant to the acquiring and using new technologies, they are forced to apply them by dental technicians, pioneers in this domain.

Without a proper organization and accommodation of these new technologies, dental office is left behind and has problems in maintain in the dental market

Institutional Review Board Statement: The study was approved by the Ethics Committee of the University of Medicine and Pharmacy of Craiova (approval date no. 197/24.11.2021).

Author contributions: All authors read and approved the final manuscript. All authors have equally contributed to this work.

Funding information: Not applicable.

Conflict of interest statement: No potential conflicts of interest concerning this study.

Data availability statement: Data availability at request

Acknowledgements: Not applicable

REFERENCES

1. Spagnuolo G, Sorrentino R. The Role of Digital Devices in Dentistry: Clinical Trends and Scientific Evidences. J Clin Med. 2020 Jun 2;9(6):1692. doi: 10.3390/jcm9061692. PMID: 32498277; PMCID: PMC7356564.
2. Ghiță RE, Stanciu A, Popescu SM, Khaddour AS, Mercuț V, Scrieciu M, Iacov-Crăițoiu MM, Drăghici EC, Cojocaru MO. Applications of CAD/CAM technology in dentistry. Rom J Dent Res. 2024;.1(1):47-56

DOI : 10.6261/RJOR.2024.3.16.5

3. Curran V., Matthews L., Fleet L., Simmons K., Gustafson D.L., Wetsch L. A Review of Digital, Social, and Mobile Technologies in Health Professional Education. *J. Contin. Educ. Health Prof.* 2017; 37:195–206. doi: 10.1097/CEH.0000000000000168.
4. De Rubertis C, Ferrante F, Stefanelli N, Friuli M, Madaghiele M, Demitri C, Palermo A. The accuracy of intra-oral scanners in full arch implant rehabilitation: a narrative review. Br Dent J. 2023 Dec;235(11):887-891. doi: 10.1038/s41415-023-6550-x. Epub 2023 Dec 8. PMID: 38066152.
5. Obădan ME, Mitruț I, Ionescu M, Obădan F, Târtea DA, Popescu MA, Popescu SM, Smarandache AM, Manolea HO. Clinical Efficacy Analysis of the Personalization of Prosthetic Abutments in Implant Supported Restorations in Comparison to Available Standard Titanium Abutments. *Journal of Personalized Medicine*. 2023; 13(9):1402. https://doi.org/10.3390/jpm13091402
6. Cervino G., Fiorillo L., Arzukanyan A.V., Spagnuolo G., Cicciù M. Dental Restorative Digital Workflow: Digital Smile Design from Aesthetic to Function. *Dent. J.* 2019; 7:30. doi: 10.3390/dj7020030.
7. Joda T., Zarone F., Ferrari M. The complete digital workflow in fixed prosthodontics: A systematic review. *BMC Oral Health.* 2017; 17:124. doi: 10.1186/s12903-017-0415-0.
8. Târtea DA, Ionescu M, Manolea HO, Mercuț V, Obădan E, Amărăscu MO, Mărășescu PC, Dăguci L, Popescu SM. Comparative Study of Dental Custom CAD-CAM Implant Abutments and Dental Implant Stock Abutments. *Journal of Clinical Medicine*. 2023; 12(6):2128. https://doi.org/10.3390/jcm12062128
9. Cojocaru MO, Drăghici EC, Khaddour AS, Ghiţă RE, Marinescu IR, Simionescu AM, Popescu SM, Scrieciu M. Frequency for the use of CBCT analysis in dentistry. Rom J Dent Res. 2024; Vol 1(Nr. 2):6-18.
10. Lazar R, Culic B, Gasparik C, Lazar C, Dudea D. The use of digital dental photography in an Eastern European country. Med Pharm Rep. 2022 Jul;95(3):305-310. doi: 10.15386/mpr-2119. Epub 2022 Jul 26. PMID: 36060504; PMCID: PMC9387581.
11. Kalpana D, Rao SJ, Joseph JK, Kurapati SKR. Digital dental photography. Indian J Dent Res. 2018 Jul-Aug;29(4):507-512. doi: 10.4103/ijdr.IJDR_396_17. PMID: 30127203.
12. Al-Hassiny A, Végh D, Bányai D, Végh Á, Géczi Z, Borbély J, Hermann P, Hegedüs T. User Experience of Intraoral Scanners in Dentistry: Transnational Questionnaire Study. Int Dent J. 2023 Oct;73(5):754-759. doi: 10.1016/j.identj.2023.04.002. Epub 2023 May 5. PMID: 37150698; PMCID: PMC10509442.
13. Angelone F, Ponsiglione AM, Ricciardi C, Cesarelli G, Sansone M, Amato F. Diagnostic Applications of Intraoral Scanners: A Systematic Review. J Imaging. 2023 Jul 3;9(7):134. doi: 10.3390/jimaging9070134. PMID: 37504811; PMCID: PMC10381333.
14. Siqueira R, Galli M, Chen Z, Mendonça G, Meirelles L, Wang HL, Chan HL. Intraoral scanning reduces procedure time and improves patient comfort in fixed prosthodontics and implant dentistry: a systematic review. Clin Oral Investig. 2021 Dec;25(12):6517-6531. doi: 10.1007/s00784-021-04157-3. Epub 2021 Sep 27. PMID: 34568955; PMCID: PMC8475874.
15. Hacker T, Heydecke G, Reissmann DR (2015) Impact of procedures during prosthodontic treatment on patients' perceived burdens. J Dent 43:51–57. 10.1016/j.jdent.2014.10.013
16. Fathi A, Rismanchian M, Yazdekhasti A, Salamati M. Accuracy of tooth-implant impressions: Comparison of five different techniques. Clin Exp Dent Res. 2023 Jun;9(3):526-534. doi: 10.1002/cre2.737. Epub 2023 Apr 12. PMID: 37042090; PMCID: PMC10280615.
17. Rutkūnas V, Gedrimienė A, Mischitz I, Mijiritsky E, Huber S. EPA Consensus Project Paper: Accuracy of Photogrammetry Devices, Intraoral Scanners, and Conventional Techniques for the Full-Arch Implant Impressions: A Systematic Review. Eur J Prosthodont Restor Dent. 2023 Jun 13. doi: 10.1922/EJPRD_2481Rutkunas12. Epub ahead of print. PMID: 37314199.

DOI : 10.6261/RJOR.2024.3.16.5

18. Haddadi Y, Bahrami G, Isidor F. Evaluation of operating time and patient perception using conventional impression taking and intraoral scanning for crown manufacture: a split-mouth, randomized clinical study. *Int J Prosthodont.* 2018; 31:55–59. doi: 10.11607/ijp.5405.
19. Guo DN, Liu YS, Pan SX, Wang PF, Wang B, Liu JZ, Gao WH, Zhou YS. Clinical efficiency and patient preference of immediate digital impression after implant placement for single implant-supported crown. *Chin J Dent Res.* 2019; 22:21–28. doi: 10.3290/j.cjdr.a41771.
20. Sailer I, Muhlemann S, Fehmer V, Hammerle CHF, Benic GI. Randomized controlled clinical trial of digital and conventional workflows for the fabrication of zirconia-ceramic fixed partial dentures. Part I: time efficiency of complete-arch digital scans versus conventional impressions. *J Prosthet Dent.* 2019; 121:69–75. doi: 10.1016/j.prosdent.2018.04.021.
21. Lee SJ, Jamjoom FZ, Le T, Radics A, Gallucci GO. A clinical study comparing digital scanning and conventional impression making for implant-supported prostheses: a crossover clinical trial. *J Prosthet Dent.* 2021 doi: 10.1016/j.prosdent.2020.12.043.
22. Muhlemann S, Benic GI, Fehmer V, Hammerle CHF, Sailer I. Randomized controlled clinical trial of digital and conventional workflows for the fabrication of zirconia-ceramic posterior fixed partial dentures. Part II: time efficiency of CAD-CAM versus conventional laboratory procedures. *J Prosthet Dent.* 2019; 121:252–257. doi: 10.1016/j.prosdent.2018.04.020.
23. Joda T, Bragger U, Zitzmann NU. CAD/CAM implant crowns in a digital workflow: five-year follow-up of a prospective clinical trial. *Clin Implant Dent Relat Res.* 2019; 21:169–174. doi: 10.1111/cid.12681.
24. Cheikh, Y., Badre, B., El. Assraoui, Kh., Karram, M.A., Khechane, Y., KAOUN, Kh., Study of Effective Dentists Communication with Laboratory Technicians in Removable Partial Prosthesis. International Journal of Advances in Scientific Research and Engineering (ijasre), E-ISSN: 2454-8006. Volume 7, Issue 1 January – 2021. DOI: 10.31695/IJASRE.2021.33959
25. Marinescu IR, Drăghici EC, Iliescu AA, Scrieciu M, Manolea HO, Popescu SM. Role of dentist-patients communication in oral rehabilitation. Rom J Dent Res. 2024; Vol 1(Nr 2):19-28. DOI: 10.58179/RJDR1202
26. Berry J, Nesbit M, Saberi S, H. Petridis, ‘‘Communication methods and production techniques in fixed prosthesis fabrication: a UK based survey.’’ Part 1: Communication, Bri. Dent. J., 2014, vol.217, no.6, pp.643 E12.]
27. Richert R, Goujat A, Venet L, Viguie G, Viennot S, Robinson P, Farges JC, Fages M, Ducret M. Intraoral Scanner Technologies: A Review to Make a Successful Impression. J Healthc Eng. 2017; 2017:8427595. doi: 10.1155/2017/8427595. Epub 2017 Sep 5. PMID: 29065652; PMCID: PMC5605789.
28. Suese K. Progress in digital dentistry: The practical use of intraoral scanners. Dent Mater J. 2020 Jan 31;39(1):52-56. doi: 10.4012/dmj.2019-224. Epub 2019 Nov 14. PMID: 31723066.
29. www.support.medit.com, 2024.
30. Rotar RN, Faur AB, Pop D, Jivanescu A. Scanning Distance Influence on the Intraoral Scanning Accuracy-An In Vitro Study. Materials (Basel). 2022 Apr 22;15(9):3061. doi: 10.3390/ma15093061. PMID: 35591397; PMCID: PMC9103333.
31. Yilmaz B, Marques VR, Donmez MB, Cuellar AR, Lu WE, Abou-Ayash S, Çakmak G, Influence of 3D analysis software on measured deviations of CAD-CAM resin crowns from virtual design file: An in-vitro study,Journal of Dentistry,Volume 118 ,2022, 103933, ISSN 0300-5712
32. Schoenbaum TR, Chang YY.’’Dentist-technician collaboration in the digital age: enhancing outcomes through photography, teamwork, and technology’’.J Calif Dent Assoc,2011, vol. 39, no. 8, pp.559-567.
33. Tran D, Nesbit M, Petridis H, ‘‘Survey of UK dentists regarding the use of CAD/CAM technology’’, Bri. Br. Dent. J.,2016, vol. 221, no.10, pp. 639–644

DOI : 10.6261/RJOR.2024.3.16.5

34. Lourenço MAG, Guimarães TM, Miranda ABS, Pazinatto RB, Calderon PDS, Melo LA, Leite FPP. Factors associated with total edentulism in the elderly and their impact on the self-perception of oral health and food. Int J Prosthodont. 2023 Oct 12;0(0). doi: 10.11607/ijp.8534. Epub ahead of print. PMID: 37824126.
35. Giuliodori G, Rappelli G, Aquilanti L. Intraoral Scans of Full Dental Arches: An In Vitro Measurement Study of the Accuracy of Different Intraoral Scanners. Int J Environ Res Public Health. 2023 Mar 8;20(6):4776. doi: 10.3390/ijerph20064776. PMID: 36981684; PMCID: PMC10048864.
36. Beuer F., Schweiger J., Edelhoff D. Digital Dentistry: An Overview of Recent Developments for CAD/CAM Generated Restorations. *Br. Dent. J.* 2008; **204**:505–511. doi: 10.1038/sj.bdj.2008.350.
37. Batisse C., Bonnet G, Bongert P., et al.''Optical Impression and Removable Partial Denture: An Accurate and Actual Solution?'', J Dent Oral Health, 2017, vol.3, no. 6, pp. 78
38. Marques S, Ribeiro P, Falcão C, Lemos BF, Ríos-Carrasco B, Ríos-Santos JV, Herrero-Climent M. Digital Impressions in Implant Dentistry: A Literature Review. Int J Environ Res Public Health. 2021 Jan 24;18(3):1020. doi: 10.3390/ijerph18031020. PMID: 33498902; PMCID: PMC7908474.

DOI : 10.6261/RJOR.2024.3.16.5