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Screw access finding after screw loosening through cemented splinted crowns on non-parallel implants using mixed reality - guided access optimization: A clinical case report

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Title:
Screw access finding after screw loosening through cemented splinted crowns on non-parallel implants using mixed reality- guided access optimization: A clinical case report.

Running Title:
Mixed Reality-Guided Screw Access in Cemented Crowns

Background: Screw loosening remains a recurring challenge in implant-supported prostheses. This is a particular problem in the case of crown restorations cemented on implants. Especially when implant required non-axial angle during implantation. To stabilize prosthetic reconstruction it requires to tighten them without damaging implant-supported structure.

Objective: This paper presents unique workflow between cone-beam computer tomography (CBCT), dental impression, 3D scan, three-dimensional (3D) segmentation and mixed reality visualization to plan and execute precise access openings for screw tightening in prosthetic implant-supported structure.

Method: Patient underwent a CBCT scan which was processed in 3DSlicer software. Additionally dental impression was done with 3D. Merged data resulted in obtaining high quality 3D model. To visualize the ideal trajectory for screw access virtual tube was created on it. Final step was to implement model in mixed reality application using Unity for Meta Quest 3 headset. Clinician evaluated model in mixed reality, verified optimal drilling angle and subsequently performed clinical procedure. This case report was prepared and reported in accordance with CARE guidelines and completed CARE checklist.

Result: Mixed reality application displaying high detailed model allowed clinician to clearly understand accurate spatial angle to drill holes in prosthesis. All screws requiring tightened were done which restored stability of implant-supported structure.

Conclusion: Utilize Mixed Reality technology to display 3D models based on CBCT scan can effectively help clinicians for planning complex prosthetic interventions when implants are done with not common technique. This can improve precision and confidence during procedure which also reduce damage on prosthetic structure.

1. Introduction

There are two types of implant-based crowns and prosthetic bridges: cemented and screwed. Due to the risk of cement residue after cementing, the former are used less and less often by doctors. Currently, in most cases, screw restorations are performed.

In the case of a cemented crown, the abutment is first screwed to the implant and then the crown is placed on the abutment with the appropriate cement.

In the case of a screw-on crown, the connection of the crown to the abutment takes place in the prosthetic laboratory. The doctor receives a crown with a fitted abutment. The crown has a hole through which a wrench is inserted to screw the crown. After screwing the crown, this hole is closed with appropriate materials.

In the case of screw-on crowns , it is therefore visible where the trepanation hole is, because the difference between the porcelain of the crown and the material closing the hole is recognizable. If the screw is loosened, it is not a problem to remove this closing material, tighten the fastener and close the hole again. On the other hand, the problem arises in the case of cemented crowns, where the position of the trepanation hole is not always located on the chewing or palatal surface.

Implant supported (screw retained) are valued for their stability and obtainability. One of the most common complications is screw loosening. It becomes very complex issue especially when implants are placed at non-parallel or angulated position and prosthetic reconstruction is cemented on implants abutments. In such cases, especially when there is a need to perform maintenance or corrective procedure it makes it very complex to access screw directly. Due to that clinical placement of implant was limited by prosthetic orientation and restoration space. This resulted in limitation of implant placement cases to very specific one's. Initially, prosthetic restorations were cemented onto abutments screwed to implants. As implant prosthetics developed, new technologies and prosthetic solutions emerged. Currently, screw-retained prosthetic restorations are most commonly used, allowing easier access in case of loosening the abutment screw and requiring retightening. The filling material in the prosthetic crown is removed, the abutment is tightened, and the trepanation hole is closed again with the appropriate filling material. Dental surgeons have access to straight or redirected wrenches, so the implant's angle is irrelevant. However, cemented prosthetic restorations pose a problem, as it's not always clear where to make the trepanation hole. While number of dental implants placed continuously grow, technology also required progress in evolution. Everything due to grow demand for functional and aesthetic rehabilitation in very challenging regions of jaws. Number of implant manufactures grown and in the same time they started to develop new system for difficult cases. Thanks to that new systems were develop such as angulated and angled screw channels. They implemented mechanical redirection which allowed clinicians to engage and tighten screws even when implants were placed on non-standard angles. This progress in technology allowed significantly expand prosthetic possibilities and reduced need for invasive bone implementation in anatomically difficult areas were amount of bone is very limited. Access

to screw channels is mostly invisible so when implant is done in straight axial trajectory it's very simple to predict were new opening in prosthetic should be done. When implantation was done in non-standard angles, it's much harder to predict were such new opening should be done to reduce and minimize damage done to prosthetic. Especially if such process is done years after prosthetic final installation, when it was done by someone else or when patient documentation does not contains any information about place of opening[i]. Achieving such trajectory becomes very demanding tasks and sometimes can lead to serious damage of prosthetic[ii]. To plan right place and angle for opening it's required to have good analytic and planning understanding with use help of three-dimensional spatial. Last year's technology in medicine had very good progress thanks to which new tools were develop and many other is still tested and progressing. Particularly integration of cone-beam computer topography (CBCT), three-dimensional (3D) modelling using segmentation tools extended with 3D scans and mixed reality (MR) allowed to show many use-cases were such tools can help clinicians during patient procedure planning and implementation[iii] [iv]. Combination of imaging data and immersive visualizations allows to plan the optimal access path before doing clinical procedure. This case report describes novel digital workflow that integrates CBCT segmented model and mixed reality visualization to assist clinician planning and executing screw tightening in 5 teeth prosthetic supported on 3 implants located non-parallel[v].

2. Case Presentation

A 65-year-old patient was referred with unstable implant-supported prosthetic. He did not report any pain. An intraoral examination and CBCT analysis revealed no pathological changes in the bone or mobility of the implants. **Noticeable bine loss was observed.** However, mobility of the prosthetic reconstruction was confirmed. According to available medical records, three AB implants were placed in 2016: a 3.2/10 implant in position 23, a 3.75/11.5 implant in position 24, and a 4.2/10 implant in position 25/26. In 2017, a porcelain bridge 0-23-24-25-0 based on metal substructure was cemented with glass ionomer cement. Available information indicates that the abutments were secured with a straight wrench. Available medical documentation includes laboratory orders, and panoramic X-rays but there was no plaster models on which the prosthetic restoration was made. The patient was presented with possible treatment options and associated complications. He decided to perform attempt of tighten the screws in existing bridge with making access holes. He acknowledge and agreed that in case procedure will fail he will need to do new prosthetic restoration.[vi]

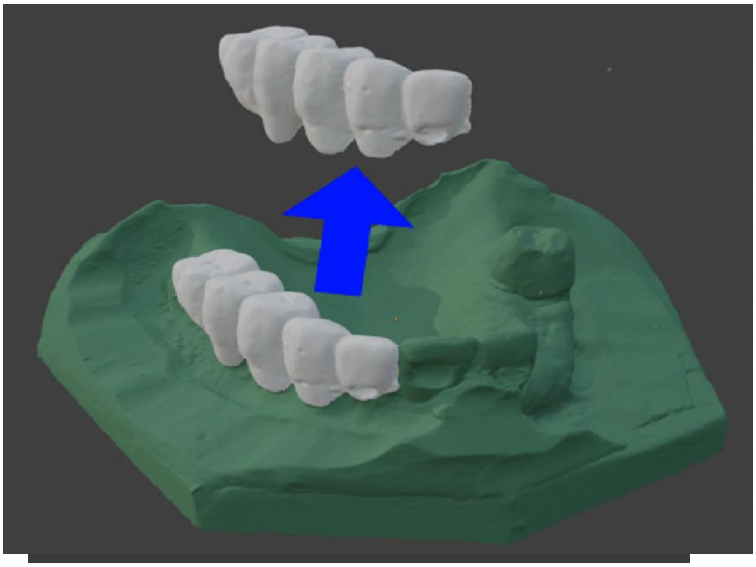


Figure 1. Model segmented from CBCT data with artefacts on bridge

3. Materials and Methods

On first stage of treatment cone-beam computer tomography was done. Quality of it allowed to perform segmentation to create 3D model. It was done using 3D slicer application[vii]. Due to material which prosthetic bridge contain (metal) it was strongly disturbing image on teeth level above the gums. Data contains to match artefacts were even with really manual approach to segmentation it was still not allowing to get acceptable level of quality for further work. Created model had very good quality of implants, screws and abutment but prosthetic bridge contain a lot of noise and distortion - visible on **Figure 1**. This was not allowing to progress further. The easiest way to get missing part of prosthetic was to get it using 3D scan. As dental office is not equipped with intra-oral scanner dental impression was taken and then making separate 3D scan[viii] in prosthetic office[ix]. Such

Figure 2. 3D scan of dental impression with separated bridge

approach allowed to get really good quality scan of prosthetic bridge without or at least with insignificant noise[x]. Prosthetic bridge was separated from scan allowing to get missing part for previously done model - **Figure 2**. Next step of entire process was to combine both models, one with implants and second with prosthetic bridge. Final step of work with model required creating precise guidance for drilled access hole to implant screw. The easiest way to achieve this was to create a tube around implant and extend it to moment when it's visible outside of teeth. **Figure 3** presents effect of created such way model. Next part was to implement display such model in Meta Quest 3 glasses[xi] [xii]. To achieve that it required to create new project in Unity application. Such project required few basic setup to allow it to be run on Meta Quest 3 and manipulate added to it model.

To build the application it was required to have Unity 6.1 engine installed with "Android Build Support" module enabled. The project was setup with basic "Universal 3D" template. As prerequisite steps, build profile was switched to Android platform and "Meta XR All-in-One

SDK" package was installed from Package Manager. Further, in project settings, "XR Plugin

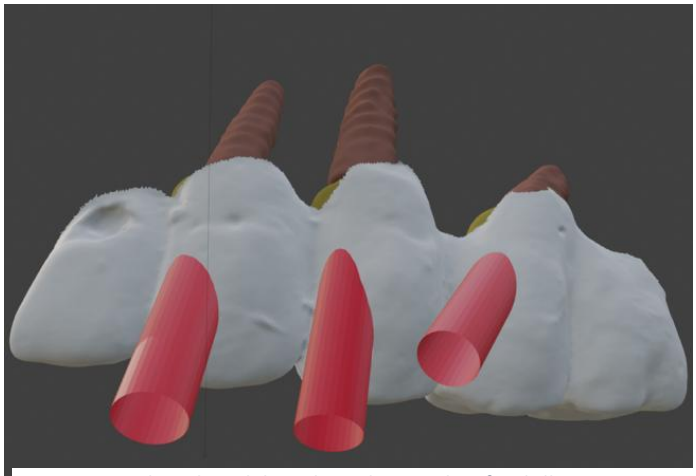


Figure 3. Combined models with guidance tubes for drilling

Manager" has been enabled with OpenXR as a Plug-in Provider. Original camera object has been removed from the project. From Meta XR Tools, three prepared Building Blocks were imported: Camera Rig (required to handle Meta Quest 3 space tracking, as well as hand and controller interactions), Passthrough (to enable real world vision in the app) and Grab Interaction. The last Building Block added a ready-to-use default interactable object. Finally, the default mesh and materials of this object were replaced with the model prepared earlier and the application was compiled and uploaded to the device[xiiixiv]. Figure 4 shows application interfaces were Mixed Reality application was prepared. As a result of entire work drilling was performed through prosthetic bridge with ~~by~~ previously analyzing guidance presented in Meta Quest 3 application. It shows holes in patient prosthetic, and two models

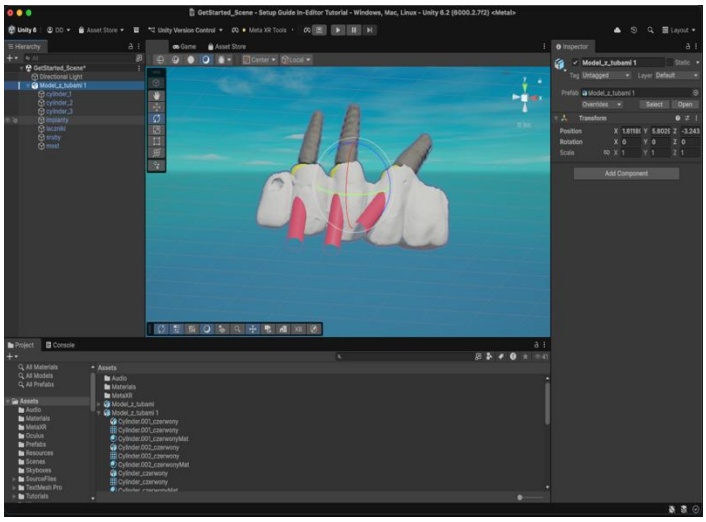


Figure 4. Unity project with model configuration

which allowed to plan such drills. One picture shows red guiding tubes with suggested angle which should be taken to perpendicularly access screw. Second picture shows expected result of drilling holes with screws (white color) inside implant. Basic overview of performed workflow is presented on Figure 5. Showing process from CBCT image, dental impression, 3D scan, model segmentation, merge and creating guidance tubes to finally implement model using Unity in Meta Quest 3 glasses.[xv]

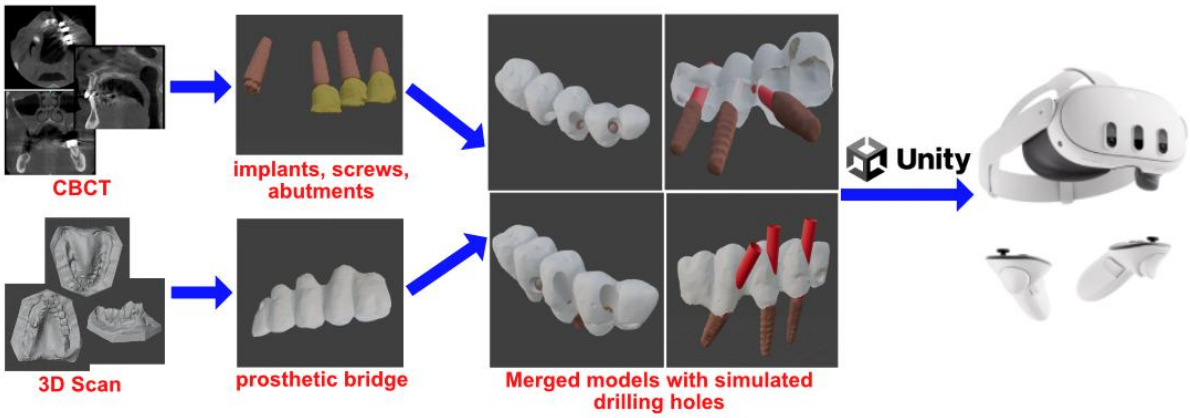


Figure 5. Workflow required to create Mixed Reality application with 3D model of prosthetic

The study was conducted in accordance with the ethical standards laid down in the Declaration of Helsinki and with applicable national and institutional guidelines. Ethical approval for the study was obtained from the Bioethics Committee of the Jagiellonian University Medical Collage (Krakow, Poland) under approval number 118.6120.161.2023. All participants involved in the study provided their informed consent prior to inclusion. Participation was voluntary, and all data were processed in an anonymized manner.

This case report was prepared in accordance with the CARE guidelines.

4. Results

Segmented 3D model using application 3DSlicer clearly shows relationship between position of implants, bone, abutments and prosthetic. Model is additionally extended with virtual tubes which were created accordingly to position of each implant allowing to visualize optimal trajectory for perpendicular access required to reach implant screw heads. Created model with additional virtual guidance (virtual tubes) was used in created mixed reality application and run on Meta Quests 3 headset. Thanks to that simulation the most optimal access path was established. Use of immersive visualization helped evaluate prosthetic geometry from any viewing angle, improving this way understanding of special constrains and challenges related to angulated implants.

All of that - workflow combination of segmented CBCT data, 3D visualization and mixed reality guidance proven highly effective assistance during planning and execution in such difficult procedure. Based on available data and preoperative planning clinician was able to perform openings with very high accuracy. Actual and planned virtual path matched each other confirming minimal deviation and allowing direct access to screw without damaging surroundings in prosthetic. Successfully all screws were re-tightened with recommended

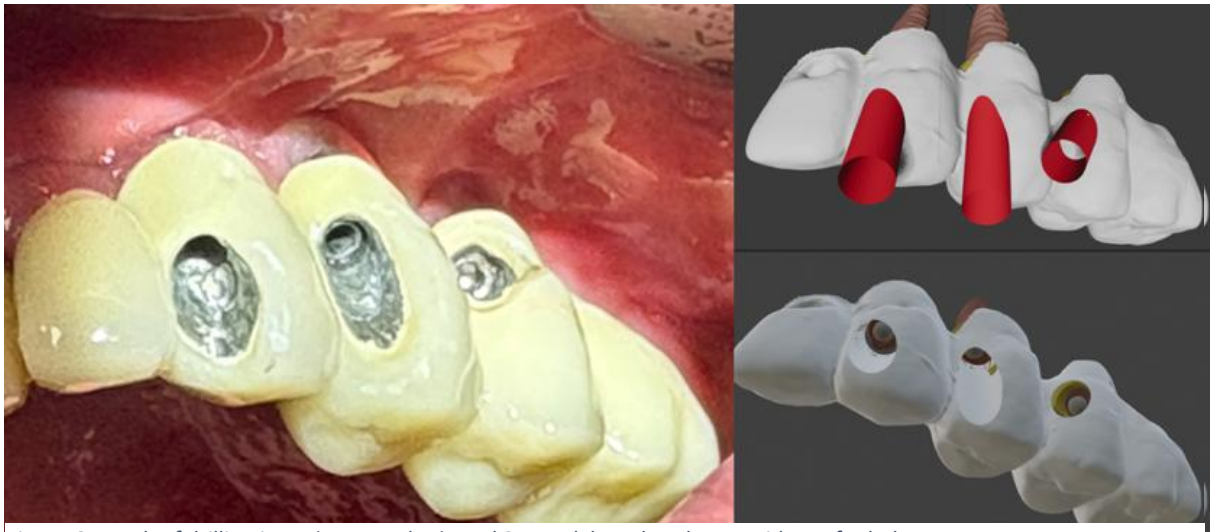


Figure 6. Result of drilling in patient prosthetic and 3D model used evaluate guidance for holes

torque which re-stabilized prosthetic. Result of this work is visible on Figure 6 including 3D visualization and exact drilled holes in patient prosthetic bridge. All opening were properly repaired and filled without leaving no traces of interference. Patient confirmed no more discomfort. On another follow up visit no mechanical or biological complication were observed. Outcome of this innovative process confirmed that mixed reality technology is very significant assistance in preoperative planning in both areas - visualization and clinical precision.

5. Discussion

Screw loosening issue is relatively uncommon problem but when it comes to management of it with existing prosthetic especially when implants are placed in angulated angle it becomes very complicated procedure. Case presented in this paper shows entire process of using digital imaging and visualization technologies proving how it can effectively increase safety and precision in prosthetic maintenance. In most of such cases clinician need to rely on their own judgment and two-dimensional radiographs. All of that provides limited information about true spatial orientation of implants in perspective to prosthetic framework. In this example use of model based on CBCT data with mixed reality visualization presents new paradigm in clinical planning. Cone bean computer tomography imagining offers very detailed data when used with right segmentation method can produce very accurate model of patient anatomy, implants and prosthetic. When such model is combined with Mixed Reality technology it can overcome limitation of traditional 3D renders on flat screen and allow clinician "step into" and "feel" spatial environment with ability to interact

with model. It can be rotated at any angle, resized to any size and move in any direction using just hand gestures. While comparing static drilling guides with mixed reality technology, it can be noticed that this technology offers much better flexibility and adaptability in compare to old way of working. Such visualization does not limits clinician to use strictly determinate template but offers dynamical visualization advice aid during entire planning and during procedure. This future is advantage when dealing with restoration guide cannot be easily determinate without removing prosthesis. Mixed Reality visualization not only becomes guidance but also allows to simulate and review all potential challenges which can happen and select the best path to avoid them. Positive result of this case can lead to conclusion that right use of available data with mixed reality technology can significantly improve spatial understanding, operator confidence and procedural precision in complex, not standard prosthetic interventions. Besides that entire workflow of this process is fully reversable so no physical modification is made until clinician is not fully satisfied with simulated plan. Concept of virtual planning match global trend in digital guided dentistry towards achieving minimal invasive treatments. However when analyzing potential of use such workflow in treatment, first several limitation need to be acknowledge. Mixed Reality visualization depends from quality of segmented model. He however depends from CBCT image quality which is strictly depended from artifacts appeared on image and mistakes done during segmentation. All of that can lead to small discrepancies between reality and simulated model.[xvi] Outside of that another challenge is need of advanced software and hardware required to use with Mixed Reality headset such as in this example Meta Quest 3. Such tools require also specialized training and can lead to limitation in accessibility in standard clinical setup[xvii]. Final difficulty is that currently such workflow can be used as planning visualization tool rather than fully integrated and validated surgical navigation system. Next years can lead to grow of this technologies and allow real-time intraoperative guidance, AI assisted trajectory prediction and direct integration with CAD/CAM prosthetic analysis[xviii]. This way it could change such innovative and experimental solution into real aid guided prosthetic visualization in surgical procedures. In summary this case clearly shows that MR technology can be promising bridge between digital imaging and clinical execution. It can lead to increasing perception understating, accuracy, safety and finally offer digital toolkit of modern implantology.

6. Conclusion

The use of mixed reality navigation using CBCT and 3D scanning of the model allowed for precise access to the screws of the connectors. Other methods are presented in the literature when it is necessary to tighten loose screws. Before the prosthetic crowns are placed, a transparent template is made with guide tubes for the drill. It is stored and used only in the event of complications. Another way to maintain the aesthetics of cemented crowns is to make screw-on crowns with a prepared cavity in CAD CAM technology, in which a highly aesthetic inlay is later cemented, closing the trepanation hole at the same time.

Both of these methods use data obtained during the production of prosthetic crowns. In vitro studies show that the most helpful in gaining access to screws with the least destruction of the crown material are: CBCT imaging with MAR, which reduces artifacts, and a 3D template with a sleeve. [xix] [xx]

Thanks to the created 3D model in MRI, the doctor can determine the position of trepanation holes and the path of the drill in real time[xxi]. This reduces the risk of iatrogenic damage to the prosthetic crown and significantly shortens the time of the procedure. The presented case shows that the combination of CBCT imaging, 3D model scan and MR is a useful tool in the treatment of complications such as loosening of the abutment screw. Especially when the crowns were performed by another doctor, there is no access to medical documentation, the implants implanted are not parallel and the location of the trepanation holes is not obvious.[xxii] [xxiii] [xxiv]

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[i] Aliane da Silva Bezerra, Anne Kaline Claudino Ribeiro, Aretha Heitor Veríssimo, Erika Oliveira de Almeida, Prosthetic complications and failures of implant-supported fixed partial dentures: A scoping review, The Journal of Prosthetic Dentistry, Volume 134, Issue 3, 2025, Pages 643-650, ISSN 0022-3913, https://doi.org/10.1016/j.prosdent.2023.10.025.

[ii] Krennmair, S., Weinländer, M., Postl, L. et al. Clinical outcome and technical complications of bimaxillary full-arch implant-supported metal-resin fixed dental prostheses with or without ceramic molars: 5-year results. Clin Oral Invest 29, 335 (2025). https://doi.org/10.1007/s00784-025-06409-y

[iii] Engelschalk M, Al Hamad KQ, Mangano R, Smeets R, Molnar TF. Dental implant placement with immersive technologies: A preliminary clinical report of augmented and mixed reality applications. J Prosthet Dent. 2025 Feb;133(2):346-351. doi: 10.1016/j.prosdent.2024.02.017. Epub 2024 Mar 12. Erratum in: J Prosthet Dent. 2024 Sep;132(3):656. doi: 10.1016/j.prosdent.2024.03.023. PMID: 38480015.

[iv] Ariel Shusterman, Rizan Nashef, Simona Tecco, Carlo Mangano, Francesco Mangano, Implant placement using mixed reality-based dynamic navigation: A proof of concept, Journal of Dentistry, Volume 149, 2024, 105256, ISSN 0300-5712, https://doi.org/10.1016/j.jdent.2024.105256.

[v] Mangano FG, Yang KR, Lerner H, Admakin O, Mangano C. Artificial intelligence and mixed reality for dental implant planning: A technical note. Clin Implant Dent Relat Res. 2024 Oct;26(5):942-953. doi: 10.1111/cid.13357. Epub 2024 Jun 28. PMID: 38940681.

[vi] Aliane da Silva Bezerra, Anne Kaline Claudino Ribeiro, Aretha Heitor Veríssimo, Erika Oliveira de Almeida, Prosthetic complications and failures of implant-supported fixed partial dentures: A scoping review, The Journal of Prosthetic Dentistry, Volume 134, Issue 3, 2025, Pages 643-650, ISSN 0022-3913, https://doi.org/10.1016/j.prosdent.2023.10.025.

[vii] Gauthier Dot, Akhilanand Chaurasia, Guillaume Dubois, Charles Savoldelli, Sara Haghighat, Sarina Azimian, Ali Rahbar Taramsari, Gowri Sivaramakrishnan, Julien Issa, Abhishek Dubey, Thomas Schouman, Laurent Gajny, DentalSegmentator: Robust open source deep learning-based CT and CBCT image segmentation, Journal of Dentistry, Volume 147, 2024, 105130, ISSN 0300-5712, https://doi.org/10.1016/j.jdent.2024.105130.

[viii] Vieira, F.L.; Carnietto, M.; Cerqueira Filho, J.R.A.; Bordini, E.A.F.; Oliveira, H.F.F.; Pegoraro, T.A.; Santiago Junior, J.F. Intraoral Scanning Versus Conventional Methods for Obtaining Full-Arch Implant-Supported Prostheses: A Systematic Review with Meta-Analysis. Appl. Sci. 2025, 15, 533. https://doi.org/10.3390/app15020533

[ix] Vieira FL, Carnietto M, Cerqueira Filho JRA, Bordini EAF, Oliveira HFF, Pegoraro TA, Santiago Junior JF. Intraoral Scanning Versus Conventional Methods for Obtaining Full-Arch Implant-Supported Prostheses: A Systematic Review with Meta-Analysis. Applied Sciences. 2025; 15(2):533. https://doi.org/10.3390/app15020533

[x] Abduo J, Rasaie V. Digital Workflows in Prosthodontics. Aust Dent J. 2025 Sep 15. doi: 10.1111/adj.70005. Epub ahead of print. PMID: 40952009.

[xi] Almashmoum M, Payton A, Johnstone E, Cunningham J, Ainsworth J Understanding the Views of Health Care Professionals on the Usability and Utility of Virtual Reality Multidisciplinary Team Meetings: Usability and Utility StudyJMIR XR Spatial Comput 2025;2:e60651 URL: https://xr.jmir.org/2025/1/e60651 DOI: 10.2196/60651

[xii] Olawale Babatunde Akinwale, Olatunde Abiona, Ayodeji Oludola Oluwatope, Olayinka Donald Otuyemi, Omotade Adebimpe Ijarotimi, Abiola Olubusola Komolafe, Stephen Babatunde Aregbesola, Babatope Ayodeji Kolawole, Olufemi Mayowa Adetutu, Ojo Melvin Agunbiade, Adeboye Titus Ayinde, Lanre Idowu, Oluseye Ademola Okunola, Alaba Adeyemi Adediwura, Designing a virtual reality system for clinical education and examination, Computers & Education: X Reality, Volume 5, 2024, 100083, ISSN 2949-6780, https://doi.org/10.1016/j.cexr.2024.100083.

[xiii] Gu, Ruizhen & Rojas, José & Shin, Donghwan. (2025). Software testing for extended reality applications: a systematic mapping study. Automated Software Engineering. 32. 10.1007/s10515-025-00523-7.

[xiv] Janecký, Dominik & Kučera, Erik & Haffner, Oto & Hricková, Lenka. (2025). Development of an Interactive VR Application Using Unity: Its Impact on Learning and Performance. 1-6. 10.1109/KI64036.2025.10916426.

[xv] Mangano FG, Yang KR, Lerner H, Admakin O, Mangano C. Artificial intelligence and mixed reality for dental implant planning: A technical note. Clin Implant Dent Relat Res. 2024 Oct;26(5):942-953. doi: 10.1111/cid.13357. Epub 2024 Jun 28. PMID: 38940681.

[xvi] Mangano FG, Yang KR, Lerner H, Admakin O, Mangano C. Artificial intelligence and mixed reality for dental implant planning: A technical note. Clin Implant Dent Relat Res. 2024 Oct;26(5):942-953. doi: 10.1111/cid.13357. Epub 2024 Jun 28. PMID: 38940681.

[xvii] Almashmoum M, Payton A, Johnstone E, Cunningham J, Ainsworth J. Understanding the Views of Health Care Professionals on the Usability and Utility of Virtual Reality Multidisciplinary Team Meetings: Usability and Utility Study. JMIR XR Spat Comput. 2025 Feb 14;2:e60651. doi: 10.2196/60651. PMID: 41340846; PMCID: PMC12671323.

[xviii] Amithasagaran, Akilan & Dakshit, Sagnik & Suryadevara, Bhavani & Stockton, Lindsey. (2025). CLiVR: Conversational Learning System in Virtual Reality with AI-Powered Patients. 10.48550/arXiv.2510.19031.

[xix] Martín Ortega N, Baños MÁ, Martínez J, Revilla-León M, Gómez-Polo M. Techniques for locating the screw access hole in cement-retained implant-supported prostheses: A systematic review. J Prosthet Dent. 2023 Jul;130(1):48-58. doi: 10.1016/j.prosdent.2021.09.030. Epub 2021 Nov 19. PMID: 34809995.

[xx] Saeed KMM, Al-Zahawi AR. A conservative approach to localize loose implant screw through cemented crown: an in vitro experimental study. BMC Oral Health. 2024 May 28;24(1):617. doi: 10.1186/s12903-024-04369-5. PMID: 38807096; PMCID: PMC11131170.

[xxi] Tarlow JL. A modified technique to locate the abutment screw access opening of a cemented implant-supported restoration. J Prosthet Dent. 2012 Jul;108(1):58-9. doi: 10.1016/S0022-3913(12)60106-1. PMID: 22765987.

[xxii] Kheur M, Harianawala H, Kantharia N, Sethi T, Jambhekar S. Access to abutment screw in cement retained restorations: a clinical tip. J Clin Diagn Res. 2015 Feb;9(2):ZD17-8. doi: 10.7860/JCDR/2015/11159.5607. Epub 2015 Feb 1. PMID: 25859535; PMCID: PMC4378818.

[xxiii] Raju K, Banu Raza F, Kumar V A. A Novel Technique to Retrieve Cement Retained Implant Supported Prosthesis with Digital Imaging: A Technical Report. J Dent (Shiraz). 2025 Mar 1;26(1):95-98. doi: 10.30476/dentjods.2024.101241.2285. PMID: 40092537; PMCID: PMC11909398.

[xxiv] Seki K, Shiratsuchi K, Toki A, Kamimoto A, Hagiwara Y. Novel Esthetic Technique for Restoring Dental Implant Access Holes: A Case Report. Dent J (Basel). 2025 Jan 26;13(2):53. doi: 10.3390/dj13020053. PMID: 39996927; PMCID: PMC11853855.