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Title

Applications and efficiency of dynamic navigation system in endodontics. A review.

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Abstract

The dynamic navigation system is a newly inducted ground-breaking technique for minimally invasive operations that was inherited from implant dentistry. DNS (Dynamic navigation system) has the potential to completely change the field of endodontics by precisely and safely performing minimally invasive operations and preventing catastrophic accidents during difficult procedures.

In this comprehensive review we examine the existing literature on the use of the DNS in endodontics to direct academics and clinicians to future DNS applications. We look at the scope, diversity, and types of applications used in present practice, find gaps in the literature, and determine where future research should be directed.

Introduction

The dynamic navigation system is a ground-breaking technique for minimally invasive operations that was inherited from implant dentistry. DNS (Dynamic navigation system) has the potential to completely change the field of endodontics by precisely and safely performing minimally invasive operations and preventing catastrophic accidents during difficult procedures. It incorporates both surgical and nonsurgical techniques with a highly directed endodontic philosophy. DNS is a specific kind of teleoperated medical robot. Tele-manipulated robots are non-autonomous master-slave robots that are guided by image-guided systems and force-feedback by surgeons. A position measuring device (a three-dimensional tracking system) and a visual user interface with therapy planning and guiding software make up DNS in most cases (1). The DNS is likened to a GPS or satellite navigation and is based on computer-aided surgical navigation technology. The DNS procedure is easy to understand. In the preoperative cone-beam computed tomography (CBCT) information submitted to the planning application, the surgeon virtually plans the appropriate drill position. A stereo tracker receives the 3D spatial data from sensors on the handpiece and the patient's teeth (2,3). This system uses CBCT pictures of the location of the virtually planned surgery and motion-tracking optical cameras to give 3D real-time dynamic navigation with visual feedback for intraoperative surgical tool guidance. Most crucially, the surgeon could modify the course of treatment in real time.

In 2019, the first literature on DNS in endodontics focused on establishing conservative access cavities and identifying canals, demonstrating its potential application in guided endodontics (4). Since then, the DNS's potential for various endodontic uses has been investigated. The DNS is currently being considered for intraosseous anesthetic, calcified canal location, endodontic microsurgery, post removal, conventional and less invasive access cavities, and the DNS. (5).

Dental researchers and surgeons have recently been interested in this technology. We examine the existing literature on the use of the DNS in endodontics to direct academics and clinicians to future DNS applications. We look at the scope, diversity, and types of applications used in present practice, find gaps in the literature, and determine where future research should be directed.

Aim of the study:

To review the uses and efficiency of dynamic navigation system in endodontic procedures.

Materials and method:

'This study is registered in research center of ‘Riyadh Elm University with IRB number FRP/**2022/470/823/789.**

Data sources

Data extraction will be carried out according to the standard Cochrane systematic review methodology. Pubmed, Web of Science, Scopus, Medline, and Embase databases was searched until September 2022, for randomized clinical trials (RCT), controlled clinical trials (CCT) and cohort studies with keywords ‘endodontic navigation’ ‘root canal treatment’ ‘dynamic navigation system.’ After an initial selection phase of the records identified from the databases, potentially eligible articles will be qualitatively evaluated to investigate the pros and cons of using navigation system for root canal therapy.

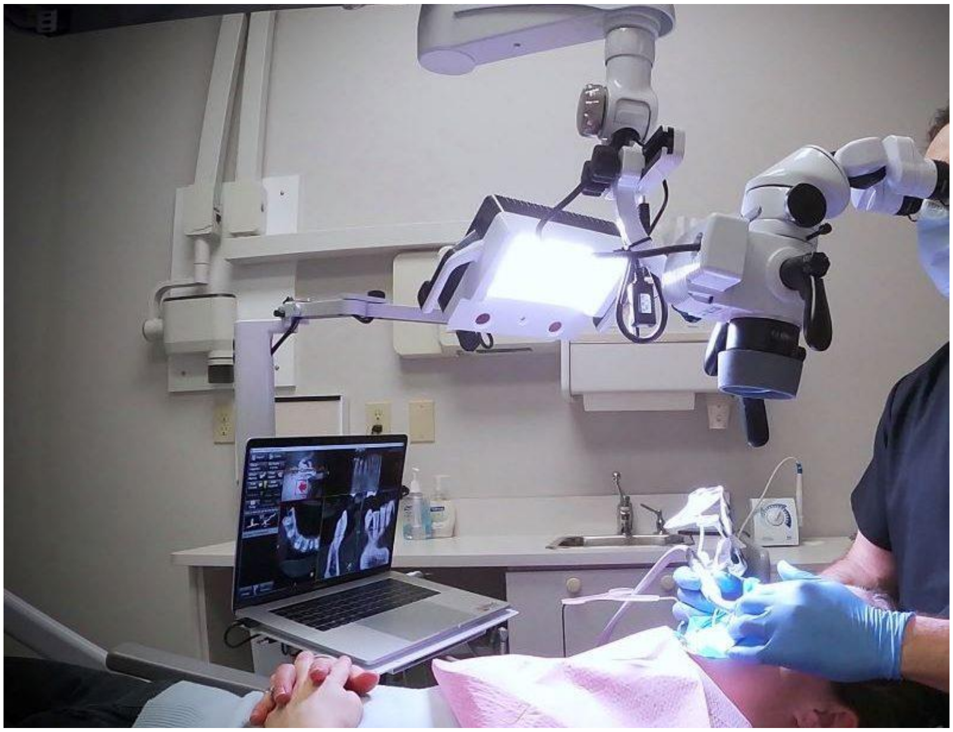
Data extraction

Screening of eligible studies, assessment of the methodological quality and data extraction was conducted independently and in duplicate. Two reviewers evaluated the references using the same search strategy and then the same inclusion criteria to the selected studies was applied.

The detailed PICO principles will be defined as follows: • Population—human teeth or three-dimensional (3D) printed teeth; • Intervention—non-surgical endodontic treatment using the dynamic navigation system; • Comparison—non-surgical endodontic treatment using the conventional freehand technique; • Outcome—accuracy and efficiency of non-surgical endodontic treatment.

	Inclusion criteria	Exclusion criteria
.	Clinical trials and randomized control studies	Systematic reviews or meta-analyses or expert opinions or narrative reviews
.	Literature published until September 2022	
.	English language of publication	Language other than English

.	In vivo (humans), In vitro studies	Animal studies



DISCUSSION

An overhead light, a stereoscopic motiontracking camera, and a computer with implant planning software are all part of the transportable equipment used by DN. These objects are used to direct a calibrated handpiece in real time until it reaches the predetermined reference point (6).

Several investigations on the accuracy of this procedure have already been conducted, despite the fact that it is still relatively new in endodontics. In one of the initial experiments chong et al have shown that dynamic navigation was successful in identifying root canals in 26 out of 29 cases on models with extracted teeth (7). Due to tracking issues, only one canal could be seen on maxillary molars in two of the three remaining teeth. The third tooth's preparation (which is also a maxillary molar) proved ineffective. Zubizarreta-Macho et al. conducted a laboratory investigation to assess the accuracy of static and dynamic navigation and compare it to freehand planning (8). The findings showed that both navigation methods outperformed freehand planning. The differences between static and dynamic navigation were negligible. It should be

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noted, though, that this study's mean angular deviation of 10° for static navigation is extremely significant when compared to prior studies.

In another study, dynamic navigation was contrasted with using freehand techniques, to determine the mesiobuccal canal on twenty copies. It was discovered that the navigated cavities were prepared more precisely in terms of angular deviation and departure from the optimal preparation. (9)

In a clinical study, Buchgreitz et al. were able to locate and negotiate the root canal and complete the root canal treatment in all 50 cases, thus confirming that the guided access cavity preparation can be performed safely. (10)

A case report by Gambarini et al showed the use of the Navident dynamic navigation system (ClaroNav, Toronto, Ontario, Canada) by an undergraduate student for bone cavity preparation and root-end resection in the surgical endodontic treatment of a lesion in an upper lateral incisor. The system allowed precise localization of the root and precise apicoectomy with a minimal invasive cavity. The dynamic navigation system allowed the student to precisely direct the bur in 3 dimensions. The osteotomy and root-end resection were easily and quickly performed by the undergraduate student with a minimally invasive approach without iatrogenic errors. The navigation system allowed the operator to precisely perform a minimally invasive osteoctomy and root-end resection during endodontic surgery. The development of dedicated surgical navigation systems for endodontic surgery could facilitate the operator's maneuvers and reduce the risk of iatrogenic errors. (11)

Advantage of DNS is that it can calibrate and track both high-speed and low speed driven burs, piezotome saws and other rigid instruments such as osteotomes or even a dental or an endodontic probe, enabling the clinician with the use of any such device for access opening and surgical procedures. The Trace Registration method (commercially known as “TaP” = “Trace and Place”) allows the dentist to register the CBCT scan to the patient by selecting three to six radiographically distinct, accessible landmarks on the screen, then tracing them in the patient’s mouth. This method eliminates the need for a special second scan to be taken with a metallic fiducial-marker affixed to the jaw with a thermoplastic stent. Aside of reducing the exposure to radiation, it reduces the chance for errors caused by stent dislocation during the scan and allows

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for the use of a small volume CBCT. Consequently, it also minimizes time and cost to the procedure. Once the handpiece and the bur are calibrated, Navident system used by the author dynamically presents on the screen the actual place and position where to initiate the access. It also shows where the tip of the bur is in real time, guiding the operator to the predetermined place to locate the canal making the location of calcified and multiple canals a faster and more accurate procedure. With the aid of this technology, smaller and more accurate accesses can be made. Preservation of valuable dentin is one of the main objectives when preforming any dental procedure. In addition, this technology will allow for the location of canals that otherwise could not be detected and negotiated with more traditional techniques. Dynamic Navigation has also the potential for assisting the surgeon in cases where apical surgery is indicated. (12).

Jain et al evaluated the potential use of high-speed drills and precision microendodontic high-speed burs with dynamic navigation to effectively prepare conservative access cavities in anteriors, premolars, and molars with simulated calcified root canals to depths as high as 21 mm and found that Optically driven, computer-aided, 3D dynamic navigation technology with high-speed drills can achieve minimally invasive access cavities in locating highly difficult simulated calcified canals with mean 2D horizontal deviation of 0.9 mm and a mean 3D deviation of 1.3 mm from the canal orifice, and a mean 3D angular deviations of 1.7 degrees.(13)

Overall, guided endodontics offers a more precise and secure treatment option than traditional freehand techniques [14] by permitting MIA and predictably locating root canals in complex cases while reducing the possibility of iatrogenic damage and enabling greater tooth structure preservation [15,16]. The dynamic method is less well supported by scientific literature than the SN technique because it was presented later [17]. The latter, however, exhibits greater potential for advancements and enhancements in the future. However, more research with a larger sample size and standardized procedures is still required to confirm the accuracy of both guided endodontics techniques [18]. Research that focuses on various clinical circumstances would also be of utmost importance. Randomized clinical trials would yield useful information on the clinical outcome of guided endodontics application, even though there are currently many case reports and few case series accessible.

Conclusion

The DNS demonstrated accuracy and efficiency in performing endodontic microsurgery, finding calcified canals, and performing minimally invasive access cavities. It also assisted in determining the best location for intraosseous anesthetic. Although introduced recently into dentistry, DNS has shown promise in the studies conducted until now.

References

1. McNamara, J.A., Brudon, W.L. and Kokich, V.G., 2001. *Orthodontics and dentofacial orthopedics* (Vol. 85). Ann Arbor: Needham Press.
2. Tamer, İ., Öztaş, E. and Marşan, G., 2019. Orthodontic treatment with clear aligners and the scientific reality behind their marketing: a literature review. *Turkish journal of orthodontics*, *32*(4), p.241
3. Vlaskalic, V. and Boyd, R.L., 2002. Clinical evolution of the Invisalign appliance. *Journal of the California Dental Association*, *30*(10), pp.769-776.
4. Bun San Chong, B., Manpreet Dhesi, B., Makdissi, J. and RCR, D., 2019. Computer-aided dynamic navigation: a novel method for guided endodontics. *Quintessence International*, *50*(3), pp.196-202.
5. Martinho, F.C., Griffin, I.L. and Corazza, B.J.M., 2022. Current Applications of Dynamic Navigation System in Endodontics: A Scoping Review. *European Journal of Dentistry*.
6. Gambarini, G.; Galli, M.; Morese, A.; Stefanelli, L.V.; Abduljabbar, F.; Giovarruscio, M.; di Nardo, D.; Seracchiani, M.; Testarelli, L. Precision of Dynamic Navigation to Perform Endodontic Ultraconservative Access Cavities: A Preliminary In Vitro Analysis. J. Endod. 2020, 46, 1286–1290.
7. Chong, B.S., Dhesi, M. & Makdissi, J. (2019) Computer-aided dynamic navigation: a novel method for guided endodontics. Quintessence International, 50, 196–202
8. Zubizarreta-Macho, A., Munoz, A.P., Deglow, E.R., AgustinPanadero, R. & Alvarez, J.M. (2020) Accuracy of computeraided dynamic navigation compared to computer-aided static procedure for endodontic access cavities: an in vitro study. Journal of Clinical Medicine, 9, 129

9. Gambarini, G., Galli, M., Morese, A., Stefanelli, L.V., Abduljabbar, F., Giovarruscio, M. et al. (2020) Precision of dynamic navigation to perform endodontic ultraconservative access cavities: a preliminary in vitro analysis. Journal of Endodontics, 46, 1286–1290.
10. Buchgreitz, J., Buchgreitz, M. & Bjørndal, L. Guided root canal preparation using cone beam computed tomography and optical surface scans – an observational study of pulp space obliteration and drill path depth in 50 patients. International Endodontic Journal, 52, 559–568.
11. Gambarini G, Galli M, Stefanelli LV, Di Nardo D, Morese A, Seracchiani M, De Angelis F, Di Carlo S, Testarelli L. Endodontic microsurgery using dynamic navigation system: a case report. Journal of endodontics. 2019 Nov 1;45(11):1397-402
12. Nahmias Y. Dynamic endodontic navigation: a case report. Oral Health. 2019;109:45-56.
13. Jain SD, Carrico CK, Bermanis I. 3-Dimensional accuracy of dynamic navigation technology in locating calcified canals. Journal of Endodontics. 2020 Jun 1;46(6):839-45.
14. Zubizarreta-Macho, Á.; de Pedro Muñoz, A.; Riad Deglow, E.; Agustín-Panadero, R.; Mena Álvarez, J. Accuracy of ComputerAided Dynamic Navigation Compared to Computer-Aided Static Procedure for Endodontic Access Cavities: An In Vitro Study. J. Clin. Med. 2020, 9, 129.
15. Ali, A.; Arslan, H. Effectiveness of the Static-Guided Endodontic Technique for Accessing the Root Canal through MTA and Its Effect on Fracture Strength. Clin. Oral Investig. 2021, 25, 1989–1995.
16. Connert, T.; Krug, R.; Eggmann, F.; Emsermann, I.; ElAyouti, A.; Weiger, R.; Kühl, S.; Krastl, G. Guided Endodontics versus Conventional Access Cavity Preparation: A Comparative Study on Substance Loss Using 3-Dimensional–Printed Teeth. J. Endod. 2019, 45, 327–331.
17. Zubizarreta-Macho, Á.; Valle Castaño, S.; Montiel-Company, J.M.; Mena-Álvarez, J. Effect of Computer-Aided Navigation Techniques on the Accuracy of Endodontic Access Cavities: A Systematic Review and Meta-Analysis. Biology 2021, 10, 212.

18. Loureiro, M.A.Z.; Elias, M.R.A.; Capeletti, L.R.; Silva, J.A.; Siqueira, P.C.; Chaves, G.S.; Decurcio, D.A. Guided Endodontics: Volume of Dental Tissue Removed by Guided Access Cavity Preparation—An Ex Vivo Study. J. Endod. 2020, 46, 1907–1912.