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Review

Protocol for a Systematic Review on the Application of Robotics in Orthodontic Treatments

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ABSTRACT

Background and Objective: Robotics have multiple uses in dentistry, especially within the field of orthodontics, though the possible applications of these innovative systems are still not well defined. The objective of this systematic review protocol will focus on describing the steps to outline the role of robotics in orthodontic treatments and define its functionality and range within clinical applications.

Methods: To achieve this, peer-reviewed studies focusing on the employment of robotic systems in various aspects of orthodontic treatment will be incorporated, while literature reviews will be not considered. Data will be explored through Scopus, PubMed, Google Scholar and DOAJ. Potential for bias will be established using the ROBINS-E and certainty assessment with GRADE guidelines.

Results: The main results of the articles included will be tabulated in an Excel spreadsheet, and a detailed narrative summary and interpretation of the data will be produced and displayed based on its use in surgical and non-surgical orthodontic treatments.

Conclusion: This systematic review protocol aims to offer important perspectives on the application of robotic systems in orthodontic procedures, contributing to advancement in clinical practices and technological integration. The results may assist practitioners in adopting robotic systems to enhance treatment precision, efficiency, and overall patient care. The literature search will encompass studies from various regions worldwide. This study is self-funded and has been registered on the PROSPERO database under the registration number CRD42023463531.

Keywords—*Robotics, Orthodontics, Clinical application, Surgical orthodontics, Orthodontic wire bending, Systematic review, Dental technology, Innovative orthodontics.*

INTRODUCTION

The term "robot" originated in 1920 from Czech novelist Karel Čapek, while "robotics" represents an intelligent fusion of perception and action, spanning multiple fields like engineering and computer science.[1,2] In recent years, robotics has profoundly impacted various facets of modern life, from industrial manufacturing to healthcare, including significant advancements in dentistry. Emerging literature highlights robotics' capability to engage, investigate, and work alongside humans, transforming oral health services and assistance.[3,4]

The robotics industry has increasingly focused on autonomous technologies, enabling minimally invasive procedures in dental operations. A notable milestone occurred in 2017 with a robot's successful completion of full dental treatment, marking robotics' integration into diverse dental specialties.[5] While relatively new in orthodontics, robots are poised to streamline routine tasks, thereby enhancing orthodontists' workflow.[6]

Exploring the role of robotics in orthodontics is essential for redefining how treatments are conducted. Integrating robotic technology has the potential to enhance patient outcomes by optimizing treatment duration, reducing human error, and improving precision in procedures such as wire bending.[7,8] Additionally, incorporating robotics into orthodontic practice could help streamline workflows by addressing challenges related to efficiency and standardization. By automating repetitive and labor-intensive tasks, orthodontists may be able to dedicate more time to diagnosis and personalized patient care.[9,10]

Moreover, robotics could contribute to expanding access to orthodontic treatment and improving its overall quality. In regions with limited orthodontic specialists, robotic systems might help increase treatment capacity, ensuring faster and more precise care. Recognizing the significance of robotics in this field is fundamental to enhancing clinical efficiency and optimizing patient outcomes, ultimately reducing complications and expediting recovery. Currently, four primary categories of medical robots have been documented—robotic surgical systems, wearable robotic devices, assistive robots, and medical robots—highlighting their growing influence in healthcare services.[11,12]

To clarify the methods to be employed, a protocol for systematic review will be conducted to offer the scientific community accurate data on the implementation of robotics in orthodontics. This protocol addresses the current scarcity of literature by summarizing the role and scope of robotics in clinical practice within the orthodontics field.

METHODS

Statement Adherence

The PRISMA recommendations[13] will be followed in the elaboration of this review and this protocol is registered at the PROSPERO site with record number CRD42023463531, accessible at https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=463531.

Research Question

What are the steps for developing a systematic review on the role and scope of robotics in clinical orthodontic practice?

Inclusion Criteria, Data Variables, and Data Sources

An exhaustive search will be conducted in Scopus, DOAJ, PubMed, Google Scholar, ResearchGate: Academic networking platform and ProQuest Dissertations & Theses Global, excluding searches for unpublished or non-peer-reviewed literature. No restrictions based on age or language will be imposed for the publications. Eligibility criteria and data items will be stablished according the PICO tool[14]; detailed information will be displayed in Table 1, while Table 2 outlines the search strategy according to the data source.

Data Collection Process

The selection of documents will be carried out through a multi-step screening process, starting with the title, followed by the abstract, and ultimately the full text. Additionally, a manual search will be conducted by reviewing the reference lists of relevant manuscripts and documents that meet the inclusion criteria. During the review, several challenges may arise, such as inconsistencies in applying the inclusion and exclusion criteria, differing interpretations of data, or issues with retrieving relevant articles from certain databases. To address these challenges, the

TABLE 1. Eligibility criteria and data variables included within the study.

PICO Element	Inclusion and Exclusion Criteria	Data Variables
P (Problem)	Inclusion: All activity related to orthodontic practice Exclusion: Activities unrelated to orthodontics	Pertains to the dental specialty that the study concentrates on
I (Intervention)	Inclusion: Implementation of devices for functional purposes in orthodontics Exclusion: Original articles focused on Artificial intelligence applications in orthodontics	Focuses on the utilization of automated systems that support orthodontic procedures practitioners
O (Outcome)	Inclusion: Benefits and drawbacks of utilizing robotics in orthodontics Exclusion: Studies that do not show practical outcomes on the implementation of robotic technology in orthodontics	Results in employing innovative technological tools to aid orthodontic treatments
S (Study type)	Inclusion: Research studies, including published and unpublished original articles, doctoral dissertations, and master's theses Exclusion: Any documents not falling within the defined inclusion criteria	Studies considered to be included within results synthesis

search process will be performed concurrently by two independent authors, each reviewing the same data source. In case of disagreements, a third unbiased reviewer will be consulted to resolve discrepancies and reach a final consensus.

TABLE 2. Search strategy.

Source	Search Strategy
PubMed: U.S. National Library of Medicine	("robot technology" OR "robot-assisted" OR "robotic systems" OR "automation in robotics" OR "robotization" OR "robotic applications") AND ("orthodontics" OR "orthodontic treatments" OR "dental alignment" OR "braces therapy" OR "orthodontic procedures")
Google Scholar search engine	"robot-assisted" AND "orthodontics" AND "dentistry"
Scopus: Abstract and Citation Database	"robot-assisted" AND "orthodontic procedures"
DOAJ Directory of Open Access Journals	"robotic systems" AND "dental orthodontics"
ResearchGate: Academic networking platform	"robot-assisted technology" AND "orthodontic treatments"
ProQuest Dissertations & Theses Global: Global database of academic theses and dissertations	"robotics applications" AND "orthodontic care"

Data collection will be carried out by the researcher who will search the database and will be validated by O.T.O. and M.A.G.R. for consensus. Data collected by the authors will be arranged in an Excel worksheet and divided into the following sections: origin and journal impact level, authors, publication year, and country of study, type or name of the robotic technology, use in orthodontics (surgical or non-surgical), purpose of the study, study results, conclusions drawn, strength and drawbacks (Table 3).[15]

TABLE 3. Table format that will be employed for data extraction.

Origin and journal impact level	Authors, publication year, and country of study	Type or name of the robotic technology	Use in orthodontics (either surgical or non-surgical)	Purpose of the study	Study results	Conclusions drawn	Strengths	Drawbacks
1st included manuscript								
2nd included manuscript								
# included manuscript								

Evaluation of Potential Bias in the Study and Assessment of the Reliability of the Evidence

To avoid potential issues with missing data or low-quality studies, the potential risk for bias will be established trough the ROBINS-E tool, and individual and overall analyses will be performed. In the absence of data, the decision for article inclusion will be determined through collective agreement. For the certainty assessment, the GRADE approach will be applied to evaluate the quality of the evidence both individually and collectively.[16,17]

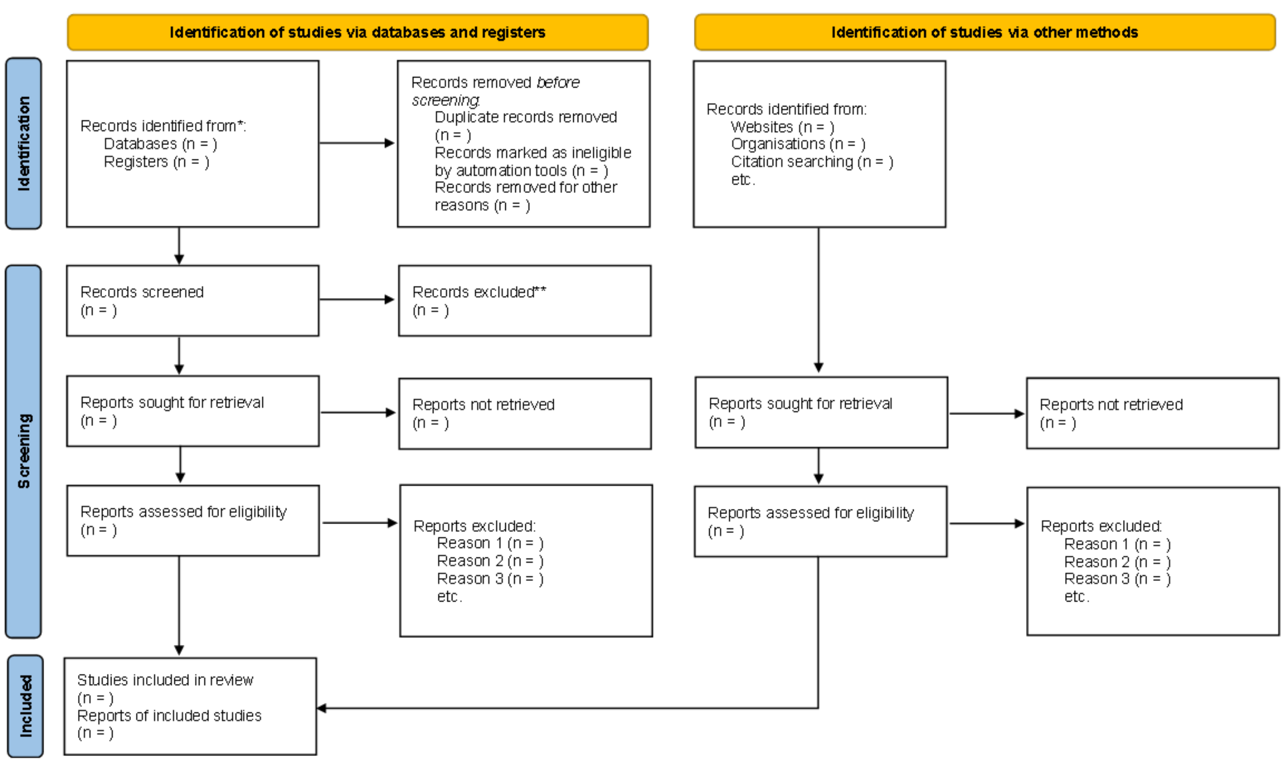

FIGURE 1. PRISMA flow selection diagram.

Approaches for Data Synthesis

A descriptive synthesis of the data will be carried out, organizing the information according to the use of robots in surgical and non-surgical orthodontic treatments. Heterogeneity will be assessed based on design of study and the specific application of robotics in orthodontics.[9]

RESULTS

This section will present the results after data collection and analysis. The flow selection will be represented with PRISMA flow diagram (2020 version)[18] for new systematic reviews, which include searches of databases, registers, and other sources, where identification, screening, and included manuscripts will be presented (Figure 1). The findings will be based on the use of robotics in surgical and non-surgical orthodontics.

Tables and figures will summarize key metrics and outcomes to facilitate comparison and interpretation. The risk of bias and certainty of evidence for each included study will be detailed.

DISCUSSION

This study aimed to summarize the methods employed for a systematic review of robotics applications in orthodontics. As a results, we obtained a comprehensive overview of the current methods and techniques used in orthodontics that incorporate robotics. The systematic review is expected to review how robotic technology is applied in orthodontic procedures, potentially providing insights into its effectiveness, precision, and impact on treatment outcomes. Additionally, it may highlight the challenges, benefits, and prospects of robotics in orthodontics, helping guide further research or development in this field.

This approach aligns with other researchers who have developed protocols for systematic reviews, aiming to clarify the methods used in emerging fields. By establishing clear and structured methodologies, these protocols help ensure that systematic reviews provide solid, reliable, and complementary research. This approach strengthens the evidence base and enhances the understanding of robotics applications in orthodontics, supporting future advancements in the field. Such systematic frameworks contribute to a more rigorous and standardized assessment of the technologies and techniques employed, ultimately benefiting clinical practice and ongoing research.[19–21]

While this review primarily focuses on robotics in orthodontics, it is important to consider complementary technologies that may synergistically enhance robotic applications. Artificial intelligence (AI), for instance, has the potential to revolutionize orthodontic treatments by improving diagnostic accuracy, treatment planning, and patient monitoring. AI can work in tandem with robotic systems, enabling more precise movements and personalized treatment strategies based on patient data.

Additionally, 4D printing, a technology that adds a temporal dimension to traditional 3D printing, could significantly impact orthodontic care by creating dynamic, self-adjusting devices that respond to the patient's anatomical changes over time. Integrating robotics with AI and 4D printing can provide a more holistic and future-proof approach to orthodontic treatments, enhancing both treatment outcomes and efficiency.

We will interpret the results in the context of existing literature, highlighting the implications for clinical practice in orthodontics. The advantages and limitations of using robotics in orthodontics will be critically evaluated. Additionally, this section will address the study's strengths and weaknesses, potential biases, and the generalizability of the findings.

CONCLUSION

This protocol is expected to contribute to elucidating a systematic review detailing robotics applications in orthodontics. It is anticipated that this protocol has been scientifically grounded, aiming to yield generalizable and valuable results to the scientific community.

AUTHOR CONTRIBUTIONS

Conceptualization: G.C.-V. and M.A.G.-R., Methodology: G.C.-V., O.T.O. and Y.L.L., Software: O.T.O. and Y.L.L., Validation: G.M.N.-R. and M.N. Á.-O., Formal Analysis: G.C.-V.

and K.J. H.-R., Investigation: G.C.-V., M.A.G.-R. and K.J.H.-R., Resources: M.N.Á.-O. and G.M.N.-R., Data Curation: O.T.O. and Y.L.L., Writing—Original Draft Preparation: G.C.-V. and M.A.G.-R., Writing—Review & Editing: G.C.-V., M.N.Á.-O. and G.M.N.-R., Visualization: Y.L.L. and K.J.H.-R., Supervision: M.A.G.-R. and M.N.Á.-O., Project Administration: G.C.-V., Funding Acquisition: M.N.Á.-O. and G.M.N.-R.

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DATA AVAILABILITY STATEMENT

Not applicable.

CONFLICTS OF INTEREST

The authors declare they have no competing interests

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

FURTHER DISCLOSURE

A section of the present manuscript has been uploaded to the Open Science Framework (OSF) portal and is available for access at the following link: https://osf.io/tn6s2/?view_only=ac2622dc1b934089906da26d4352aa49. This repository provides access to relevant details of the research and can be consulted by those interested in exploring the methods and findings prior to formal publication.

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