Semi-Automated Oral Hygiene System for Immobilized Patients

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ABSTRACT

Limited mobility, elevated risk of infection, and caregiver burden hinder oral hygiene maintenance in immobilized patients. Older patients, victims of trauma, and neurologically impaired patients are most likely to have difficulty in maintaining oral hygiene and become susceptible to infections, gingivitis, and plaque buildup. Existing automated systems do not have built-in features like suction, toothpaste dispensing, brushing, and flossing. Manual care, on the other hand, is time-consuming and physically taxing for caregivers. To address these challenges, this study proposes a semi-automated oral hygiene system that integrates suction, automated toothpaste delivery, brushing, and flossing in a unified design. Through the integration of automated suction, toothpaste dispensing, brushing, and flossing, the system provides thorough hygiene with minimal physical labor. Functionality and safety are assured by a rigorous design process involving patient and carer assessments, conceptual development, prototype integration, and clinical validation. The technology provides a feasible solution to long-term care environments by improving patient well-being and reducing carer stress, and clinical trials are underway to maximize its impact in home and institutional environments. Future prospects include telemonitoring and AI-driven customisation.

Keywords: Oral care; immobilized patients; semi-automated system.

1 INTRODUCTION

An essential part of healthcare is the practice of good oral hygiene, especially for patients who are bedridden and cannot take care of their teeth independently. In these individuals, poor oral hygiene could lead to severe side effects such as systemic infection, dental caries, and periodontal disease [1]. When a person cannot brush and rinse effectively, they require assistance from a career, which is not always convenient or effective. Various automated oral care devices have been proposed to solve this issue, offering innovative means of enhancing oral hygiene in individuals with limited mobility [2], [3].

Early models of automated oral hygiene devices focused on motorized brushing systems that enabled hands-free cleaning, but the concept has since evolved considerably. One such innovation is the University of Mississippi Dental Care System (MDCS), which employs an

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automated toothbrush with a water and toothpaste dispenser built into it to enable patients to clean their teeth independently [1]. Relative to traditional hand brushing methods, research has proved that these kinds of devices are effective in reducing plaque development and improving gingival health. Their overall adoption, however, has been constrained by limitations such as poor suction designs and low ability to accommodate other oral structures [4], [5], [6].

Personalized oral trays and ultrasonic cleaning technology are newer developments that enhance user comfort and effectiveness [7]. To facilitate thorough cleaning with minimal effort, [8] introduced an automatic oral cavity cleaning device with a thermoplastic tray accommodating both the upper and lower jaws. The work designed a dental hygiene device that integrates a control system with a sucking cannula to facilitate brushing and fluid removal simultaneously, reducing the risk of aspiration. Similarly,[9] introduced a medical oral care device that integrates a timing device and control mechanism to optimize brushing time, thereby enhancing oral hygiene maintenance. The incorporation of suction units into oral hygiene devices has been a major innovation for immobile patients. By designing a device with an internal liquid container and air suction system, [10] developed this concept further and enabled more effective removal of trash and more effective application of cleaning solutions.

Our design extends these advances with the development of a semi-automatic toothbrush for bedridden patients. It has a mouth lifter, a U-shaped brush, and a suction unit for post-brush cleaning. The design features automatic water and toothpaste dispensers and a vibration motor for effective plaque removal. Our solution is superior to previous devices since it employs suction technology, ensuring complete cleaning and preventing fluid buildup. The purpose of this invention is to provide individuals with difficulty in caring for their own oral hygiene an effective and practical oral care system.

2 MATERIALS AND METHODS

2.1 SYSTEM DESIGN

Fig.1 shows the brushing mechanism, which is a U-shaped toothbrush with motor-driven vibrating bristles. A potentiometer provides users with a means to adjust the vibration level, with a convenient cleaning process. For improved functionality, the system includes a fluid dispensing and suction unit. A relay-controlled toothpaste dispenser releases a set quantity of toothpaste onto the brush, and a water dispenser is released for rinsing. When brushing is done, the suction unit effectively clears excess fluids from the mouth, leaving the mouth clean and comfortable. Such actions are synchronized with an Arduino Nano microcontroller, which controls motor use and relay switching. Debounce logic is applied for effective detection of button presses to prevent unwanted activations.

Mechanically, the apparatus is constructed on a wooden or acrylic platform for support. Water and suction units are attached with flexible tubes to ensure free flow of fluids without any blockage. For portability and ease of use, the apparatus can be used at home or in a hospital. In

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addition, the system also has variable parameters, i.e., motor speed and brushing time, to enable the system to become applicable for various patient needs.

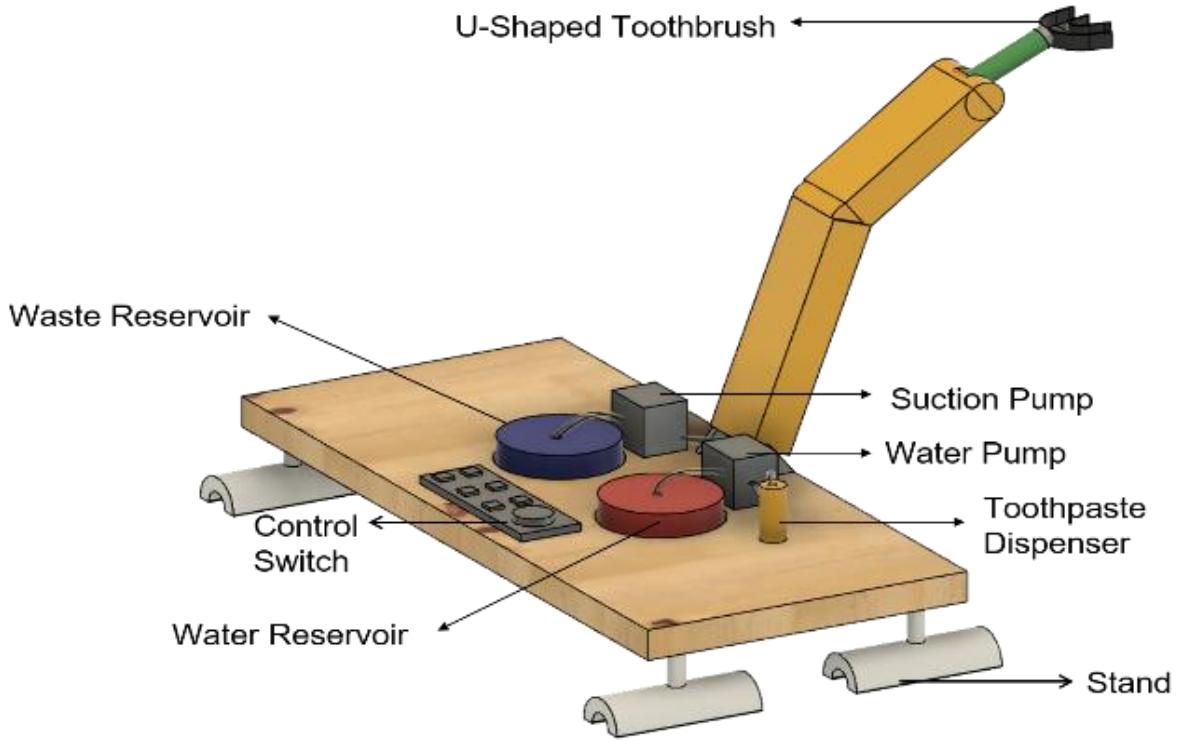

Fig 1: 3D Model of Proposed Design

2.2 WORKING PRINCIPLE

The Fig 2 describes the work flow of the system operation. The toothbrush is semi-automatic and works using a sequential operation driven by an Arduino Nano microcontroller. The system is put into operation upon a button being pressed, commencing the process of brushing. When activated, the system initially provides a pre-determined volume of liquid toothpaste onto the U-shaped toothbrush via a relay-controlled dispensing motor. The user can also control the vibration level through a potentiometer to provide a comfortable cleaning experience. The microcontroller subsequently energizes the vibration motor, which oscillates the bristles and initiates the brushing action. After the brushing cycle is over, the system turns off the vibration motor and goes into the rinsing cycle. A water dispensing unit dispenses a set quantity of water for mouth rinsing. The dispensing motor is turned off to avoid excessive fluid flow.

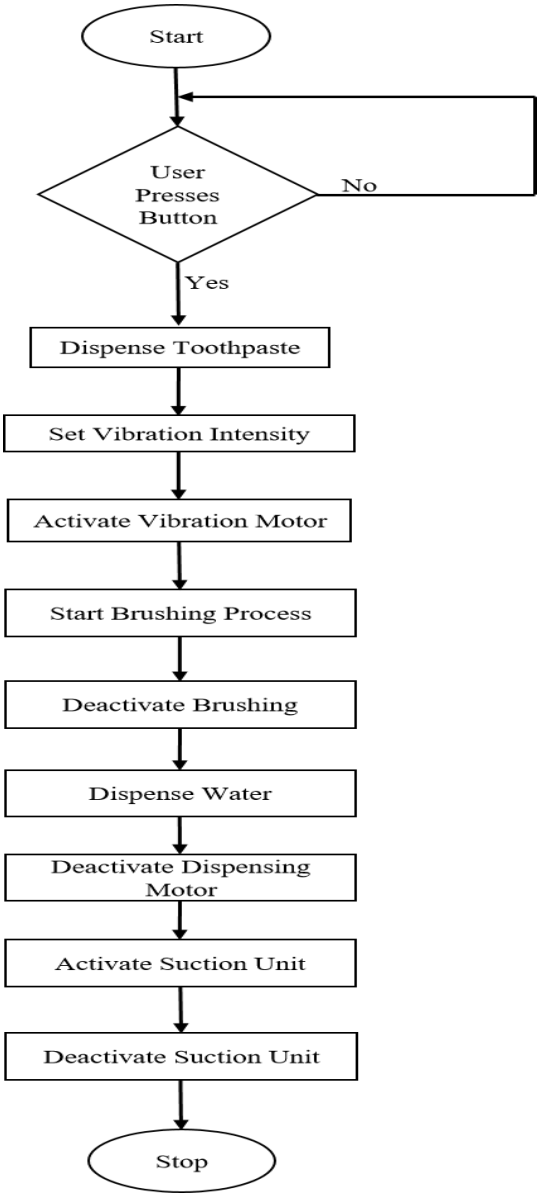

Fig.2: Flowchart of the System

Then, the suction unit is activated to suck out any remaining water and toothpaste from the user's mouth, thereby making the process mess-free and clean. Lastly, the suction unit is deactivated, ending the process. The system is founded on a systematic process, as can be seen in the flowchart, thus providing a smooth and automated brushing process suitable for bedridden patients in the clinical and home settings.

2.3 PROTOTYPE DEVELOPMENT

The system was designed through an iterative design process, with input from caregivers, patients, dentists, and engineers. Surveys and consultations were done to determine particular needs and design factors. The prototype combines automated flossing, brushing, toothpaste dispensing, and suction to provide a one-stop oral care solution. Material selection aimed at durability, hygiene, and patient comfort. Individual components were tested prior to system-wide integration to provide the best performance and safety.

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2.4 TESTING AND VALIDATION

Functionality testing was performed to assess the performance of the system in executing automated oral hygiene operations. Brushing effectiveness was determined in terms of vibration intensity and cleaning coverage. Toothpaste dispensing consistency was quantified to guarantee proper volume per use. Water flow control was confirmed for accurate rinsing functionality, while suction performance was tested to ascertain effective removal of debris and excess fluids. Future clinical studies in healthcare facilities will yield greater understanding of system usability, patient comfort, and long-term benefits on patient oral health and caregiver workload. Enhanced features include customization through AI-driven algorithms and remote monitoring to continue optimizing oral hygiene management in institutional and home-based settings.

3 RESULTS AND DISCUSSION

The device effectively performs brushing, toothpaste application, rinsing, and disposal processes in a systematic order under the control of an Arduino Nano microcontroller. The U-shaped bristles that are designed to fit the user's dental structure ensure effective cleaning with minimal human intervention. The additional feature of a vibration motor whose intensity can be controlled by a potentiometer enables users to personalize their brushing experience. The toothpaste dispensing is controlled by a motor operated by a relay, which dispenses an accurate amount of toothpaste onto the bristles. The process prevents wastage and provides an even application. After completing the brushing cycle, the system automatically shuts off the vibration motor and initiates the rinsing cycle. A water pump, which is operated by another relay system, dispenses an appropriate amount of water to help in mouth cleaning. The water flow governed by the regulator delivers proper rinsing of the patient's mouth. The suction process of the system is initiated following rinsing to evacuate waste material from the patient's mouth. After suction is finished, the system is shut down by the user.

4 CONCLUSIONS

The development of a semi-automated oral care system for immobile patients is a major advancement in patient care, focusing on a critical but most often neglected aspect of care. Through automating basic oral care functions such as brushing, toothpaste delivery, water rinsing, and waste evacuation, the system ensures proper and uniform oral care and reduces physical and psychological stress on caregivers. The innovation not only improves hygiene but also patient dignity, comfort, and overall well-being. In addition, the effective use of this system can also translate into overall oral health gain, thus reducing the risk of secondary complications such as infection and systemic disease. The potential for future innovations, such as the use of sophisticated sensors in oral health monitoring, adaptive cleaning devices, and transportable units for diverse healthcare settings, illustrates the scalability and flexibility of

this technology. The integration of this system with current healthcare infrastructures can also enhance patient care further through remote monitoring and tailored treatment. Overall, this semi-automated oral hygiene system sets a new benchmark for patient-centered technologies, highlighting the use of technology in enhancing healthcare accessibility, efficacy, and inclusivity for the mobility-impaired.

5 DECLARATIONS

5.1 Competing Interests

The authors confirm that there is no conflict of interest

5.2 Study Limitations

Limitations including the requirement for additional clinical testing, flexibility in accommodating various patient needs, and dependence on the monitoring of caregivers. May lead to potential risks of choking accidentally, gum irritation, or mechanical breakdown.

5.3 Publisher's Note

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REFERENCES

[1] F. Jg, R. Gw, C. Rw, G. Rs, C. Ea, and R. Eh, "Oral hygiene for the severely handicapped: clinical evaluation of the University of Mississippi dental care system," *Spec. Care Dent. Off. Publ. Am. Assoc. Hosp. Dent. Acad. Dent. Handicap. Am. Soc. Geriatr. Dent.*, vol. 8, no. 6, Dec. 1988, doi: 10.1111/j.1754-4505.1988.tb00754.x.

[2] M. Irving, R. Stewart, H. Spallek, and A. Blinkhorn, "Using teledentistry in clinical practice as an enabler to improve access to clinical care: A qualitative systematic review," *J. Telemed. Telecare*, vol. 24, no. 3, pp. 129–146, Apr. 2018, doi: 10.1177/1357633X16686776.

[3] M. Estai, Y. Kanagasingam, M. Tennant, and S. Bunt, "A systematic review of the research evidence for the benefits of teledentistry," *J. Telemed. Telecare*, vol. 24, no. 3, pp. 147–156, Apr. 2018, doi: 10.1177/1357633X16689433.

[4] C.-H. Yeh *et al.*, "Comparison Between Powered and Manual Toothbrushes Effectiveness for Maintaining an Optimal Oral Health Status," *Clin. Cosmet. Investig. Dent.*, vol. 16, pp. 381–396, Oct. 2024, doi: 10.2147/CCIDE.S490156.

[5] Y. Jain, "A comparison of the efficacy of powered and manual toothbrushes in controlling plaque and gingivitis: a clinical study," *Clin. Cosmet. Investig. Dent.*, vol. 5, pp. 3–9, Feb. 2013, doi: 10.2147/CCIDE.S40656.

[6] S. Palanisamy, "Innovations in oral hygiene tools: a mini review on recent developments," *Front. Dent. Med.*, vol. 5, Aug. 2024, doi: 10.3389/fdmed.2024.1442887.

[7] F. Buleu, "Innovations in Oral Care Technology: How New Gadgets Can Improve Your Routine", Oral Health Case Rep 10 (2024): 147.

[8] J. Ohayon, "Dental hygiene device for bedridden patient in hospital, has evacuation device with sucking cannula, and control device commanding functioning of projecting device and sucking device simultaneously," FR2852228 (A1), Sep. 17, 2004 Accessed: Jul. 24, 2025.

[9] "Oral cavity cleaning device, particularly for bedridden patients," 6186782, Feb. 13, 2001 Accessed: Jul. 24, 2025. [Online]. Available: https://www.freepatentsonline.com/6186782.html

[10] M. A. Roziq, S. Sukini, and D. Fatmasari, "Enhancing Motivation for Oral Hygiene Implementation among Immobilized Compos Mentis Patients through The Development of a Dental Care Table in Inpatients Settings," *Int. J. Adv. Health Sci. Technol.*, vol. 4, no. 3, Art. no. 3, Jul. 2024, doi: 10.35882/ijahst.v4i3.329.