Research Article

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Robotic Use in Orthodontics: Literature Review

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ABSTRACT

Background: *In orthodontic treatment there is always a need to improve efficacy and efficiency of appliances. Improvement of the orthodontic appliances would improve the general dental treatment, thus changing the standards of the oral health.*

Aims: *The aim of this study was to compare the traditional wire bending in fixed orthodontic appliances with the robotic made wire. Also, to check if robot wire bending is superior and has better results than traditional wire bending.*

Materials and Methods: *All articles published from 2010 to present day were included in the study,as the robotic made wire came in use at this time. Databases including MEDLINE via Ovid, Web of science, Embase, Cochrane Library and LILACS were used as the main sources of our data.*

Results: *In this study 7 papers were found to fit our inclusion criteria. It was found that the use of a robot to bend an archwire in the process of making a fixed appliance increases the treatment accuracy, efficacy and efficiency. Also, it decreases the treatment time and patient discomfort thus improving the orthodontic treatment in general.*

Conclusion: *Orthodontic treatments which use a robot or machine to twist archwires utilized in fixed orthodontics apparatus will have a greatly improved forecast with remarkably shorter treatment time in comparison to the traditional approaches.*

Keywords

Robotic, Orthodontics, Dentistry.

Introduction

A robot is a special machine programmable by a computer capable of carrying out series of complex actions automatically [1]. Robots can be controlled by an external or internal control device or with an embedded-in control. Nowadays, robots are used in industrial fields, manufacturing processes, medical fields, military purposes and research. Importantly, a wide range of robots is being developed to assess in a variety of roles in the medical environment [2].

Other uses of robots are: Minimally invasive surgery, a more controlled and precise surgical manipulation, in which magnification provides better vision for the surgeon and shorter hospital stays for recovery. Similarly, Dentistry has seen enormous enhancements and progressions from the customary methods to the advanced world that has augmented the extent of dental treatment and systems [3]. It can realize the following functions: the manufacturing of complete or partial denture, dental implantology,

and the bending of archwires. The experience and technique between the dental specialist and the technician are integrated into the software of dental expert system [4].

Developments in three-dimensional imaging and manufacturing processes have made the customization of orthodontic appliances to improve treatment efficiency possible. Advances in technology have yielded two patient-specific products that utilize computers to create an interactive treatment plan, and then manufacturing a custom-designed appliance, such as: the Insignia® system (Ormco Corporation, Orange, CA, USA) and Suresmile® archwires (OraMetrix, Inc., Richardson, TX, USA) [5].

Review of the Literature

Robots have many applications in the orthodontic field and the following are the most common techniques that utilize the use of robots.

Insignia

The Insignia framework furnishes clinicians with software that helps them plan and draw the final occlusion, and afterward sections and archwires are figured out to move teeth to the ideal result (Figure 1). The organization offers patient-specific brackets, indirect-bonding transfer jigs, and custom archwires. The custom archwires are made by a printing robot that uses the system provided to trace and bend the wire accordingly (Figure 2), the robot is very accurate and has a very small error margin [5].

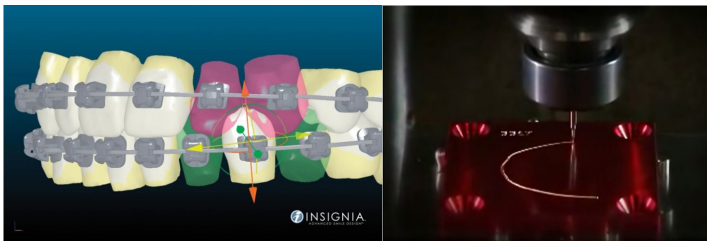


Figure 1: Insignia system software. **Figure 2:** Wire fabrication robot.

In 2009, an Insignia client Dr. David Sarver prescribed the Insignia framework because of its “ability to design treatment as individually as possible, rather than a '1 size fits all' approach. It allows us to truly plan treatment with the end in mind". Recently a clinical report has been published on the principle highlights and the clinical focal points of the Insignia framework. They showed the treatment efficiency of the system while treating a 16-year-old male who gave a Class II malocclusion for 17 months without the need to rebond the sections or curve the archwires. The records of 35 cases treated with the Insignia framework were contrasted with 11 cases treated traditionally, as far as the nature of the outcomes and treatment times [5].

The American Board of Orthodontics (ABO) scores were bring down in the Insignia gathering, showing that the completed outcomes were nearer to those characterized by the perfect ABO criteria. Furthermore, the mean treatment time was fundamentally shorter in cases treated with Insignia (14.23 months versus 22.91 months), and those patients were dealt with by means of around seven less arrangements all things considered than the ordinarily treated patients. It was stated that the sample size of the routinely treated group was little and that the underlying companion evaluation rating scores were low in the two groups. In this manner, the outcomes of this investigation may not have any significant impact on patients with progressively extreme malocclusions. Randomized clinical trials with bigger sample sizes are required, to survey the viability and productivity of the Insignia custom bracket system [5].

Suresmile

The procedure starts with the orthodontist to utelize digital images of a patient's mouth and teeth taking by either a white light scanner or cone beam computed tomography (CBCT). Then he takes the teeth and exclusively adjusts them into the correct position. The 3D image information is sent to a computer for further refinement. The location and tension required for the brackets and wire are sustained into the computer by the dentist and the data is sent by Internet to the SureSmile office. At this stage, the robots come in; the orthodontic wire is grasped by two automated pliers, which warms and twists the wire into a pattern that will manage the teeth into their favored position [6].

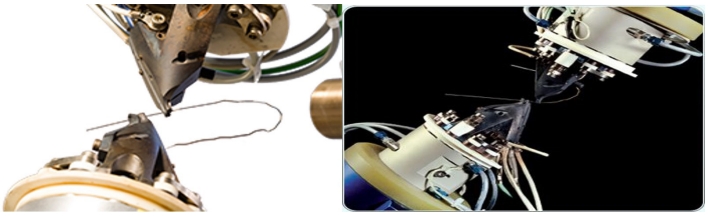


Figure 3: Suresmile archwire bending robot.

SureSmile is an all-advanced system which utilizes new 3-D imaging and PC systems for diagnostics and treatment planning and uses mechanical technology to modify fixed orthodontic appliances [6].

LAMDA system

A lingual archwire manufacturing and design aid (LAMDA) for the precise, fast plan, and bending of orthodontic archwires, which appeare in Figure 4. This system can just understand the movement in XY plane, so it can't bend the archwire with a closed loop [6].

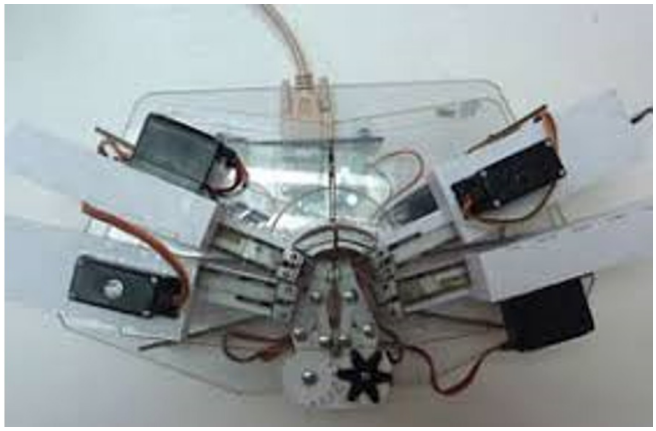


Figure 4: LAMDA system.

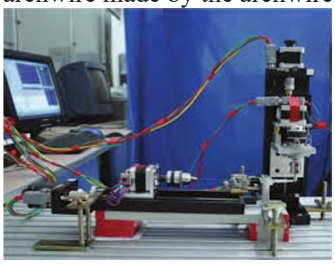
MOTOMAN UP6

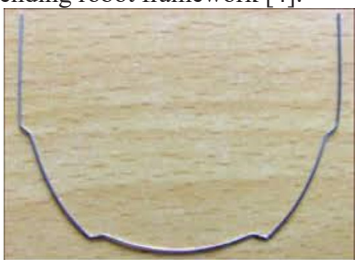
Another sort of archwire bending robot depends on MOTOMAN UP6 is made out of computer and archwire bending actuator (Figure 5). This is associated with the MOTOMAN robot end and is utilized to balance out and bend the archwires. The different items examined by this robot; incorporate bending position, point of enhancement of the curve wire, the kinematics and bending properties [7].

Figure 5: Archwire bending robot based on MOTOMAN UP6.

Cartesian type archwire bending robot

Archwire bending robot component is made out of the base, the turning, feed, and supporting structure of archwire, bending die, and archwire bending system (Figure 6). The bending procedure of orthodontic archwire is examined and the structure of orthodontic archwire bending robot is designed utilizing Solid-works software. Precision control with a third-order pure acceleration/deceleration (acc/dec) profile of archwire bending robot is set up. Orthodontic archwire bending experimentation is performed utilizing Cartesian sort archwire bending robot. Figure 7 demonstrates the orthodontic archwire made by the archwire bending robot framework [4].





Figures 6 & 7: Cartesian type archwire bending robot.

The difficulties of future application of robotics in dentistry

Basic Requirement of Design: with the assistance of three-dimensional oral character the bending of archwire is realized consequently by the limited space robot. Fundamental trouble of the structure and assembling for robot in orthodontics is whether it can fulfill the interest of the distinctive patient's mouth attributes after oral fix.

For orthodontics archwire bending robot, orthodontics archwire should be quantitatively communicated. Archwire spring-back and bending point's planning should be broken down to understand the precise archwire bending [6].

Research Difficulty: Function of the application of robot in orthodontics is unique, so the research trouble additionally isn't identical. Research trouble of orthodontics archwire bending robot system is spring-back analysis and bending algorithm of archwire and generation of customized orthodontics archwire [6].

Future Development on Application of Robot in Orthodontics: Advancement has been made in the research of the use of robot in orthodontics, yet it isn't finished. Viewing from the state of the art of utilization of robot in orthodontics and the market request of oral cavity fix, the following researches are highly recommended.

A- Novel Structure: High flexibility, reliability, and accuracy are required for the robot in orthodontics, however the workspace is restricted by the oral cavity. The adaptability and the restricted workspace are one set of technical inconsistencies, so the all outplanning and advancement to the robot is essential. In the precondition of fulfilling the oral cavity fix, reducing of the degree of freedom of the robot is essential.

B- Sensor and Control Technique: For orthodontics archwire bending robot, the research in the future would focus on archwire spring-back and bending algorithm.

C- Human Computer Interaction Technology: Human-PC cooperation innovation is one of the key advancements of movement control of the robot in orthodontics. For orthodontics archwire bending robot, the research later on spotlights on three-dimensional virtual showcase of customized orthodontics archwire on the screen, a virtual perception condition for a planned customized orthodontics archwire, and the position's intuitive change of various loops. For the robot in orthodontics, it is hard to recognize the working condition and understand the activity with different obstacles in unstructured environment. For encouraging the task, a sort of well-disposed human-PC connection programming should be introduced to provide adaptation info and input to the administrators [6].

The aims and objectives of this literature review is to differentiate between the results of traditional wire bending in fixed orthodontic appliances and the robotic made wire and to check if robot wire bending is superior and has better results than the traditional wire bending.

Materials and Methods

This study is a literature review based study. The inclusion criteria, all studies conducted during the year 2010 up to June 2019. The databases which were searched, included MEDLINE via Ovid, Web of science, Embase, Cochrane Library, LILACS. The exclusion criteria were articles in other language than english, editorials, letters to the editor, experimental studies with animals

and short communications were excluded from this review.

Data collection procedure

The databases were searched using the keywords: robotics in dentistry, orthodontics and robots, archwire bending robots, robotic use in orthodontics. The possible articles for inclusion were identified and collected.

Ethical consideration

Ethical approval was obtained from Ras Al Khaimah Research and Ethics Committee and favorable ethical opinion was obtained from the Ministry of Health and Prevention Research Ethics Committee; under reference number (REC-21-R-2018-UG-D).

Results

Study process

Study process: the databases (MEDLINE via Ovid, Web of science, Embase, Cochrane Library and LILACS) were searched; a total number of 95 articles were identified as potential sources of information. After the initial screening (round 1) only 13 articles were selected. In the second screening round 6 articles were excluded as they do not answer all of the inclusion criteria requirements. Threfore, only 7 articles were included in the research according to inclusion criteria as shown in the flow-chart (Figure 8) and (Table 1 and 2).

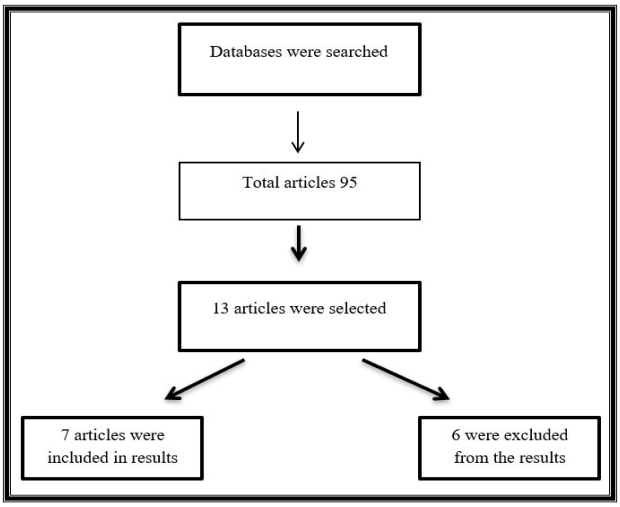


Figure 8: Flow diagram of the method of data collection.

	Author	Title	Year	Journal	Result
1	Jin-Gang Jiang, et al.	A Review on Robot in Prosthodontics and Orthodontics	2014	Advances in Mechanical Engineering	-improving reproducibility, efficiency, and quality of orthodontic treatment - accurate and rapid design
2	Ahmad S. Kh and Drogomyretska	A Glance about the Applications of Robot in Orthodontics.	2016	International Journal of Innovation and Scientific Research	-improving reproducibility, efficiency, and quality of orthodontic treatment - accurate and rapid design
3	Aldrees, A.	Do customized orthodontic appliances and vibration devices provide more efficient treatment than conventional methods?	2016	The Korean Journal of Orthodontics	reduction in the total treatment time with the use of robots in archwire bending
4	Alford. T, et al.	Clinical outcomes for patients finished with the SureSmile™ method compared with conventional fixed orthodontic therapy.	2011	The Angle Orthodontist	Suresmile® was associated with a shorter treatment time, and resulted in a lower ABO cast-radiograph evaluation score
5	Kumar, P	Future Advances in Robotic Dentistry.	2017	Journal of Dental Health, Oral Disorders & Therapy	improved and precise treatment with good quality of work in a less amount of time
6	Jiang. J, et al	Recent Advances in Orthodontic Archwire Bending Robot System.	2016	Recent Patents on Mechanical Engineering	can improve the bending accuracy and efficiency of personalized archwire and promote the development of orthodontics
7	Gilbert. A	An In-Office Wire-Bending Robot for Lingual Orthodontics	2011	Journal of clinical orthodontics	A 16th orthodontist performed a blind evaluation of the 30 archwires, assigning a score between zero and 10 to each wire based on how well it adapted to the cast. The mean score for the 15 manually bent archwires was 6.9; the mean score for the 15 archwires designed and manufactured with the LAMDA system was 9.0

Table 1: Included article:

	Author	Title	Year	Journal	Reason of exclusion
1	B Divya Bhat, et al.	Robotics in dentistry: Fiction or reality	2017	Journal of Dental Research and Review	Related to general dentistry not orthodontics
2	Gilbert H and Webster III R	Rapid, Reliable Shape Setting of Superelastic Nitinol for Prototyping Robots.	2016	IEEE Robotics and Automation Letters	Not focusing on the same idea
3	Rigelsford J	Robotic bending of orthodontic archwires	2004	Industrial Robot: An International Journal	Before 2010
4	Jha Kukreja, B, et al.	Robotic dentistry- the future is at the horizon	2012	Journal of pharmaceutical and biomedical sciences	Not focusing on the same idea
5	Zhang Y and Jiang J	Analysis and Experimentation of the Robotic System for Archwire Bending	2011	Applied Mechanics and Materials	The study about robotic system not the robot itself
6	Mah J and Sachdeva R	Computer-assisted orthodontic treatment: The SureSmile process	2001	American Journal of Orthodontics and Dentofacial Orthopedics	Before 2010

Table 2: Excluded article.

Discussion

This topic was selected to differentiate between the results of traditional wire bending in fixed orthodontic appliances and the robotic made wire. Furthermore, we aimed to find out whether the robot wire bending is superior and has better results than the traditional wire bending. Orthodontics has always tried to improve the efficacy and efficiency of appliances. Since its inception, many modalities have been changed and improved over time to increase the quality to the highest degree.

All articles since 2010 were used for the research because robotic made wire approximately came in use at this time. The databases including MEDLINE via Ovid- Web of science- Embase- Cochrane Library- LILACS were found to be quite explicit and were very helpful for the current research.

This study found that the use of a robot to bend an archwire in the process of making a fixed appliance increases the treatment accuracy, efficacy and efficiency., This result was supported by several recent studies that were conducted to evaluate the use of robots or machines to bend archwire to be used for the orthodontic fixed appliances to the desired shape. The latter researches concluded that the use of a robot can improve the reproducibility, efficiency and the quality of the orthodontic treatment when compared to the conventional archwire manufacturing [4,6,7,8]. The practitioners have scored a mean grade of 6.9 that was compared to a robot that scored a mean grade of 9 in case of accuracy [9,10].

Also, in this study it was found that the use of a robot in the archwire bending process is a rapid and accurate design process that can enhance the treatment time and the patient comfort.. Therefore, the use of robots to bend the archwire is a very good option, rather superior to the conventional methods in selecting the treatment options and this was supported by a number of studies [4-7].

Regarding treatment time, this study has found that the treatment time is improved significantly when the process of archwire bending involves specialized robots. In contrast, a study suggested that the use of a robot to bend an archwire can decrease the treatment time. However, this is probably truefor the simple cases as the study was not performed on a severe malocclusion cases but involved only mild cases [11].

Conclusion

This review has concluded that the orthodontic treatment which uses a robot or a machine to bend archwires for the fixed orthodontic appliances will have a much better prognosis with a remarkable less treatment time compared to the conventional method, in which a technician instead of a machine bends archwires, yet with increased accuracy and decreased patient discomfort. The most common techniques that use the robots in archwire bending are Insignia and Suresmile, which both have proven their superiority compared to other techniques.

Acknowledgment

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