行政院國家科學委員會專題研究計畫 成果報告

先進牙髓病根管治療專用精密機器人之發展(第 2 年)
研究成果報告(完整版)

計 畫 類 別 ：個別型
計 畫 編 號 ：NSC 96-2221-E-009-147-MY2
執 行 期 間 ：97 年 08 月 01 日至 99 年 07 月 31 日
執 行 單 位 ：國立交通大學機械工程學系（所）

計 畫 主 持 人：洪錫源

報 告 附 件 ：國外研究心得報告
出席國際會議研究心得報告及發表論文
國際合作計畫研究心得報告

處 理 方 式 ：本計畫涉及專利或其他智慧財產權，2 年後可公開查詢

中 華 民 國 100 年 01 月 05 日

行政院國家科學委員會補助專題研究計畫成果報告

先進牙髓病根管治療專用精密機器人之發展

Intelligent Micro Robot Development for Minimum Invasive Endodontic Treatment

計畫類別：* 個別型計畫

計畫編號：NSC96－2221－E －009－147－ MY2

執行期間：97 年 8 月 1 日至 99 年 7 月 31 日

執行機構及系所：國立交通大學機械工程系

計畫主持人：洪錫源教授

共同主持人：Prof. Gunnar Hesselgren, Columbia University

Prof. Janet Dong, University of Cincinnati

計畫參與人員：呂宗熙教授, 林芳宇, 曹智強, 黃子耀,
王建智, 李偉民, 吳偉仁, 陳有毅, 何昇融,
葉人瑜, 陳冠宏

成果報告類型(依經費核定清單規定繳交)： *完整報告

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中 華 民 國 99 年 11 月 4 日

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40816

DESIGN OF Z AXIS ACTUATOR & QUICK TOOL CHANGE ASSEMBLY FOR AN ENDODONTIC MICRO ROBOT

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University of Cincinnati
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ABSTRACT

Although the technology of endodontic therapy (root canal treatment) had developed for many years, it is still operated by hands. A typical treatment procedure includes access preparation (opening crown with drills), root canal shaping and cleaning, and then root canal filling. This treatment is expensive, time-consuming, and prone to human error. The outcome relies on the clinician's skill, which is gained through years of training and practice. The success quotient of this treatment is 60-65% for general dentists and 90% for specialists (endodontists). Therefore, an Advanced Endodontic Technology Development project was initiated. The goal of this project is to develop an intelligent micro robot and a computer aided treatment system to execute the endodontic treatment automatically. It is expected that this intelligent micro robot system will overcome the problems encountered in current treatment practice and increase the treatment accuracy and efficiency.

This paper briefly describes the Advanced Endodontic Technology Development project followed by the design of the micro robot for the root canal treatment. The paper focuses on the design of the Z axis actuator to control the treatment tool's motion and quick tool change assembly in the micro robot.

INTRODUCTION

In the United States approximately 24 million teeth undergo endodontic therapy every year [1]. Endodontic treatment is performed to prevent a tooth from being a source of infection. This treatment involves drilling through the crown of the tooth to the canal in which the root resides. The nerve pulp is then removed, the canal is cleaned and shaped, and then a filler material is inserted into the cleaned canal. The hole originally drilled into the tooth is then filled and sealed over.

Typically, endodontic treatment involves root canal preparation and root filling. The root canal preparation, better known as preparing the root canal for root filling, can be divided into three phases: (1) access preparation, (2) coronal canal preparation, and (3) apical canal preparation. Figure 1 shows canal characteristics and the three phases in canal preparation for a posterior tooth.

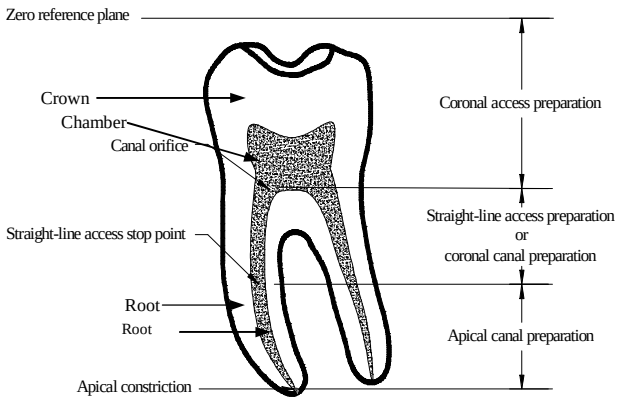
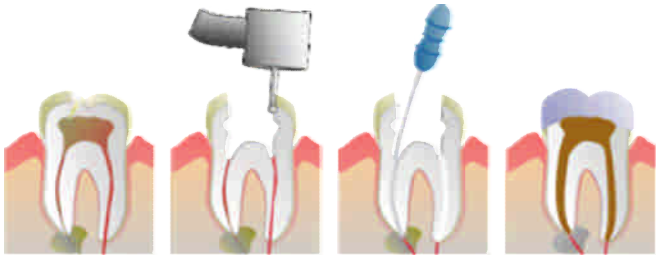


Figure 1. Canal Characteristics and Three Phases in Root Canal Treatment Preparation



(a) (b) (c) (d)

Figure 2. (a) Infected tooth, (b) Opening crown using bur, (c) Shaping root canal using file (d) Sealed tooth with fillings

The endodontic access preparation is to create an unimpeded passageway to the pulpal space and the apical

portion of the root canal [2]. By using an access bur attached to a high-speed turbine hand-piece, the chamber is unroofed, and canal orifices are exposed, see Figure 2 (b). In order to obtain instrument control, the straight-line access to the apical portion of the root canal is created during access and coronal canal preparation [3]. Coronal and apical canal preparation is also called root canal cleaning and shaping. Successful cleaning entails the use of various instruments, the first will physically loosen and remove soft and hard tissue; the second is an irrigating system to flush loosened materials away, and the third will inject chemicals to dissolve the infection from the inaccessible regions, see Figure 2 (c). Root canal shaping is a mechanical process accomplished with a variety of instruments. This process is to establish a continuously shaped conical form from apical to coronal to facilitate the filling of the root canals with gutta-percha cones and sealer that are today's most commonly used filling materials [4], Figure 2(d). The successful outcome of the preparation depends largely on the clinician's expertise, including his/her tactile sense and judgment. To expose the canal orifices and establish a straight-line access to the canal, a relatively large amount of the tooth structure must be removed during access preparation. This removal can be excessive and may weaken the tooth. There are also additional problems that can occur in the current endodontic techniques for canal preparation [5] [6], such as Perforation and Furcal Perforation-This causes periodontal (surrounding tissues) destruction, weakens tooth structure, and often-subsequent loss of the tooth; Canal Ledging-This is an artificially created irregularity in the surface of the root canal wall that prevents the placement of instruments of proper length into the original canal path; Transportation of the Apical Portion of the Canal-Characterized by a normal curved canal that has been straightened, especially in the apical third[5].

The problems identified cannot be resolved solely by training. Endodontics is a clinical specialty, but the great need for endodontic therapy makes it impossible for these specialists to handle all cases. These problems have created a need for advanced endodontic technology innovation by applying advanced engineering and computer aided technology to reduce the potential for human error and improve the quality of dental care. The need for advanced endodontic technology prompted the research of "Advanced Endodontic Technology Development." The Advanced Endodontic Technology Development project consists of four sub-subjects [6]:

(1) Development of a technique to thoroughly assess the tooth's condition using 2-dimensional x-ray images to build a computer 3-D tooth model, displaying state-of-the-art computer graphics;
(2) Develop an automatic prescription system from the 3-D root canal model, using computer-aided treatment procedure planning;
(3) Design and build a smart multi-purpose precision micro machine to perform automated root canal treatment;
(4) Develop a new ultrasonic cleaning tool with pressure assisted jetting/vacuum waste removal.

The development of an endodontic micro machine is the center piece of the Advanced Endodontic Technology Development project. With on-line monitoring and intelligent control, the micro machine or robot will perform the automated drilling, cleaning, and filling of the root canal. All other sub-project results will be incorporated into this robotic operation.

This paper describes the design of this micro machine for endodontic treatment. The focus is on the designs of Z axis actuation system for control of the tool motion and tool change assembly with quick changing mechanism in the micro machine.

DESIGN OF ENDODONTIC MICRO ROBOT

Specific objectives for micro robot design include: (1) reducing the reliance on the skills of the dentist, (2) minimizing human error, and (3) offering a method for precise diagnosis and treatment. A preliminary quantitative study established the design requirements. To provide accurate positioning of tools, with correct angular orientation, an ideal basic machine must have five degrees of freedom to control the following axes [7]:

- X-axis, along the teeth row, with travel range of 5 mm;
- Y-axis, across the teeth row, with travel range of 4 mm;
- Z-axis, the tool advancement direction, perpendicular to the tooth occlusal surface, with a travel range of 15 mm minimum. When using a longer tool, the endodontic tool should be able to reach 28 mm from the tooth crown, covering the required range of treatment;
- The angular adjustment of the tool entrance angle of ± 12° in the X-Z plane;
- The angular adjustment of the tool entrance angle of ± 12º in the Y-Z plane.

In addition, the design must meet the following requirements:

- The size of the machine must be compact enough to fit into the patient's mouth and sit on the teeth between his/her two jaws. The dimension should be within 20 mm x 20 mm x 28 mm;
- The spindle must have the rotational power to drive the tool at speeds and torque used in endodontic treatment tools;
- The machine should be able to provide a thrust force not less than 500g (4.9 Newtons) for tool penetration into the crown and dentin.

The machine has a saddle-shaped base. It will ride on a pair of reference brackets and the teeth. Before taking X-rays and mounting this machine, the brackets, in assorted sizes to fit the patients' teeth must be pre-clamped firmly on the tooth to be

treated. Neighboring teeth may be used as support. The bracket pair provides three radiopaque reference points for the machine registration, thus establishing a coordination system. Once the machine is seated on the reference bracket, the machine base will have no motion relative to the patient's teeth, regardless of the patient's head or jaw movements. The machine is designed to be compact and rigid so that the patient can bite on it. Figure 4 shows the endodontic micro machine mounted on the lower teeth. There is no need for the patient to actively keep his/her mouth wide open, nor is there a need for the patient to keep his/her head absolutely still. There are no sharp corners to hurt the patient, and a protective case will further enhance the safety.

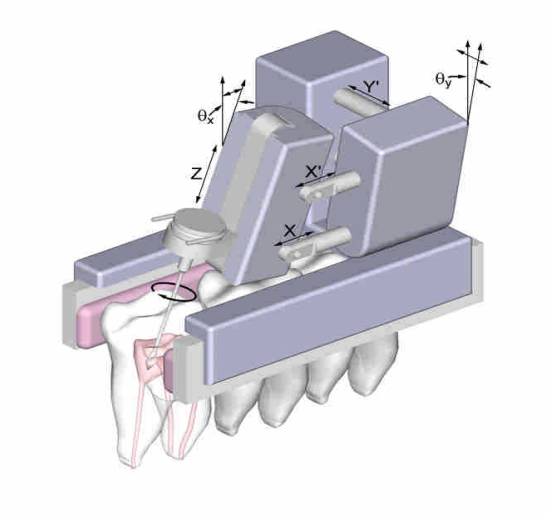


Figure 3. Multi-purpose Micro-machine for Automatic Endodontic Treatment

Designed for multi-purpose use, this machine can hold various endodontic tools and auxiliary devices. With a quick tool change approach, utilizing a cartridge design, different tools can be pre-mounted on a small modular unit, which can be inserted into a steel ribbon holding or tool mounting plate on the Z axis.

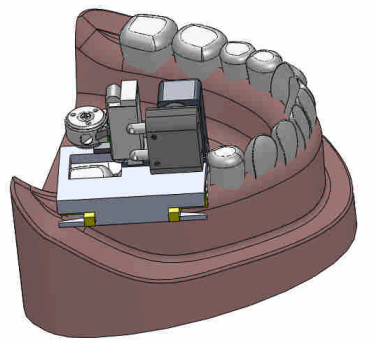


Figure 4. Endodontic Micro Machine Mounted on a Lower Teeth

Z AXIS ACTUATOR DESIGN FOR CONTROLLING THE TOOL MOTION

The Z axis is the tool moving direction which leads the treatment tool going upwards and downwards to get into the root canal. Based on the dentin and crown materials, a minimum 500 g push force is needed in order to invade the dentin and crown. Since the electric motor with the micro size needed to fit into the human mouth could not provide such power, a hydraulic system is designed to actuate the tool motion in Z axis. The design of Z axis actuator is shown in Figure 5. It consists of cylinder housing, front cover, back cover, two half circle tracks, piston, steel ribbon and steel ribbon holder (tool quick change assembly mounting plate). The steel ribbon is used to drive the motion of the tool with one end connect to cylinder piston and other end connected to tool assembly mounting plate. The ribbon size and thickness was calculated to meet the strength requirement from the hydraulic power to the root canal. The motion of the steel ribbon including the position and speed were controlled by the hydraulic cylinder/piston displacement.

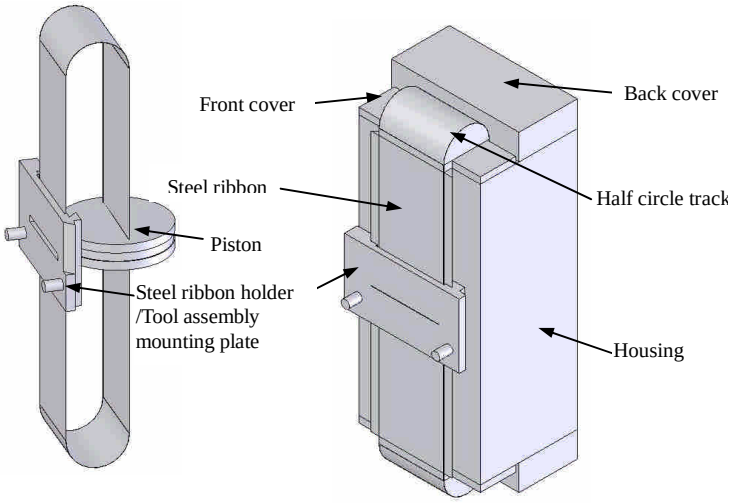


Figure 5. Z Axis Actuator and Steel Ribbon Drive System

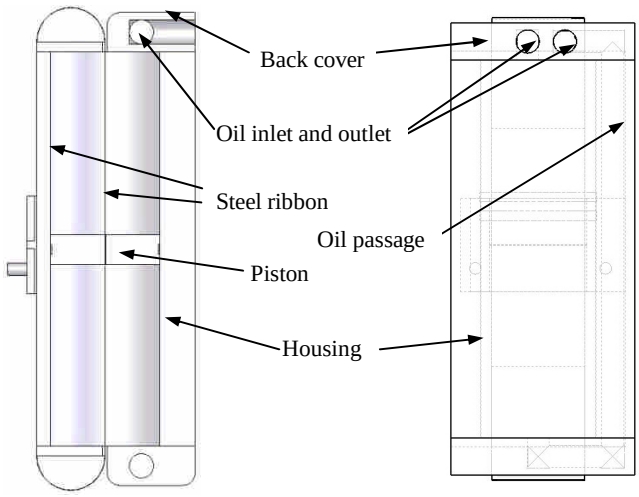


Figure 6. Z Axis Actuator – Side view and Back View with Oil Flow Illustration

There is an oil flow system inside the back cover. Steel ribbon is connected to the cylinder piston on one end and goes around semicircle tract connected to steel ribbon holder through dove-tail slot. In addition to hold the steel ribbon and transmit the motion, the steel ribbon holder is also used to mount the treatment tool assembly with two pins as reference points (datum). The steel ribbon holder is designed 7.1mm wide, 0.8mm thick and 4 mm high. Piston diameter is 5 mm with 2 mm in height. The ribbon thickness is 0.01 mm and 4 mm wide [8]. In order to reducing the number of oil cable coming out from the machine (inside the mouth) and the oil volume needed, the oil inlet and outlet of cylinder is designed close to each other with two entrance/exit needed. The oil goes from inlet to the bottom and comes up to the outlet. The inlet and outlet will connect to the oil deliver system from outside cable. Considering the safety vegetable oil will be used as the pressure media and cylinder is sealed completely.

TOOL QUICK CHANGE ASSEMBLY DESIGN

The tool quick change assembly is the tool holding device with quick tool change mechanism. The whole assembly will be changed based on the need of the tool type. Sample tools need to be changed include bur for opening the crown, file for shaping the root canal, filling needle for filling materials into the root canal, and probes used to sense the inner situation of the root canal. The goal of design the tool quick change assembly is to design a device with minimum tool change time to increase the treatment efficiency. In order to achieve the goal a quick change mechanism was designed which not only make the tool quick change possible but also provides convenient way to change tool inside a human mouth. The tool change assembly is shown in Figure 7. It consists of cover, housing, tapered sleeve, impeller, tool holder, bearing, seal, spring and screws.

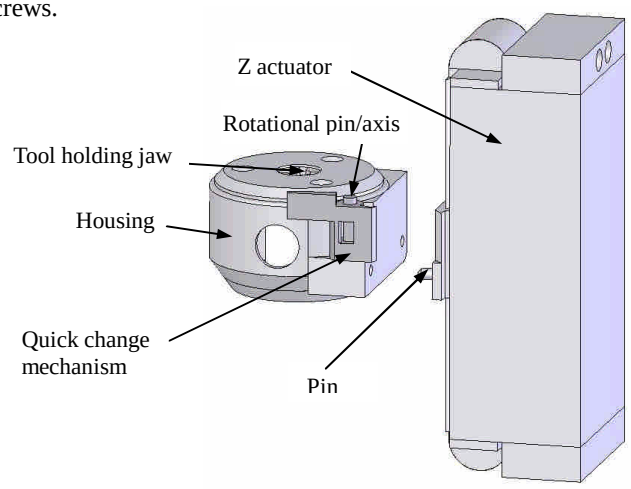


Figure 7. Tool Change Assembly with Quick Change Mechanism

The quick change mechanism is also attached to the assembly. It can be used to different tool assemblies. The pin on the tool assembly is the rotating axis for the quick change mechanism. There are also holding bracket, torsional spring, and pressure tab in the quick change mechanism. Through the rotation motion of holding bracket by torsional spring and applying pressure on pressure tab, the quick change assembly is connected or released from the Z actuator. The first step to connect tool quick change assembly to the Z actuator is to make two holes in the tool assembly fit with two orientation pins on the steel ribbon holder in the Z axis actuator. Two holes, two pins and contact surface of tool change assembly to the steel ribbon holder form a reference coordinate system. This reference coordinate system makes every tool used for the treatment have the same positions. When release tool change assembly from the Z axis actuator, gently touch the pressure tab and apply force on the tab, holding bracket will rotate away from the holding plate and change assembly will separate from Z axis actuator.

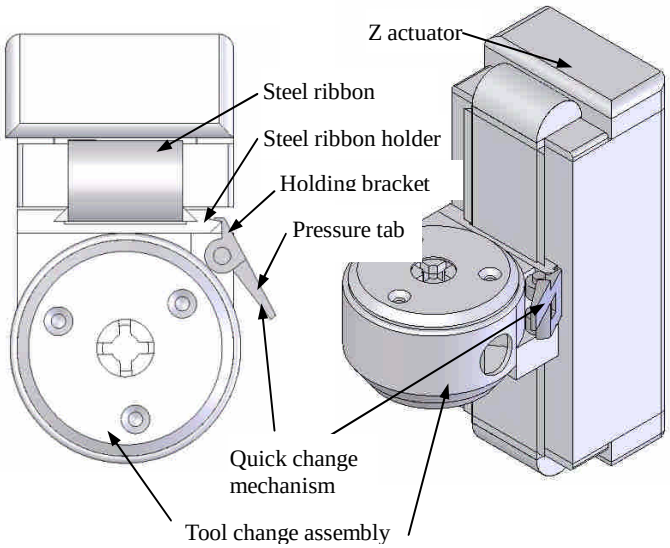


Figure 8. Tool Change Assembly Connected to Z Axis Actuator Through Quick Change Mechanism (top view and iso view)

The completed design of micro machine for root canal treatment is shown in Figure 9 with its sitting on a teeth model. There are five cables connected to the machine: three oil cables for controlling the motions in X, Y and Z axis, two air cables for controlling the rotational motion of tool and provide air to clean the root canal. Oil flow and pressure will determine the position and speed of tool motion in X, Y and Z direction. Air pressure and volume will determine the rotational speed of treatment tool.

CONCLUSION

Although the technology of endodontic therapy (root canal treatment) had developed for many years, it is still operated by hands. The Advanced Endodontic Technology Development project was initiated to make the manual treatment to science-based automation. The development of an endodontic micro

machine is the center piece of the Advanced Endodontic Technology Development project. With on-line monitoring and intelligent control, the micro machine or robot will perform the automated drilling, cleaning, and filling of the root canal.

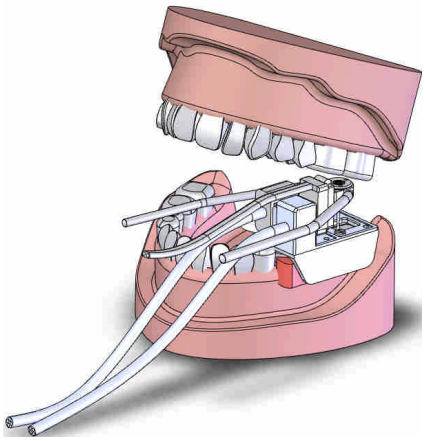


Figure 11. Endodontic Micro Robot Mounted on the Teeth

This paper describes the design of Z axis actuator and tool quick change assembly in the micro machine for root canal treatment. Z axis actuator provides the power for tool motion in Z axis or root canal direction. Tool quick change assembly holds the treatment tool and can be changed quickly based on the treatment need. The Z axis actuator along with X axis and Y axis actuators and their power delivery system completes the control of the tool motion for the treatment. The design of X axis and Y axis actuator will be discussed in a separated paper. There are many different tools used during the root canal treatment. They are held by the tool change assembly with 4 jaw design. Quick change attachment makes tool change possible and convenient during the treatment process. The pressure tab and holding bracket design reduces the tool change time therefore increases the overall treatment efficiency.
Next step will be manufacture Z axis actuator and tool change assembly with quick change attachment and tested for functions, positioning accuracy, seal, and speed control. Further modification of design maybe needed after the testing.

ACKNOWLEDGEMENT

This paper is a result of the NSC96-2221-E-009-147-MY2 project on " intelligent micro robot development for minimum invasive endodontic treatment " sponsored by National Science Council, Taiwan, Republic of China.

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國科會國際合作計畫出差心得報告

計畫編號: NSC96－2221－E－009－147－MY2

計畫名稱:先進牙髓病根管治療專用精密機器人之發展
出差日期: 98 年 7 月 15 日至 99 年 7 月 20 日

出差地點: 美國**紐約市哥倫比亞大學牙醫學院**

出差目的: 與哥大及辛辛那提大學合作團隊討論國合計畫技術進展

一、國外差旅經過

本人於 98 年 7 月 15 日從新竹出發，7 月 16 日到達紐約，稍事休息，於當地 7 月 17 日星期四在哥倫比亞大學牙醫學院(照片 1)與我們的國際合作夥伴，該校的牙隨科系主任的哈索格蘭教授(照片 2)以及他的研究及臨床團隊見面(照片 3)，向他簡報目前計畫最新進展，展示我們所做的機器人零件組合，並邀請他來台回訪。隔天 7 月 18 日星期五 Dr. Hasselgren 帶我進入哥大附設醫院 Vanderbilt Clinic of Dental School, 實地探討目前牙醫病患根管治療實例，並試驗我們所發展的先進牙髓病根管治療專用精密機器人在臨床上可能遭遇的問題。7 月 20 日星期日美國不上班，但是 Prof. Janet Dong, University of Cincinnati 從 Ohio 趕來紐約因此三方面聚首討論整個計畫的未來方向，並草擬給 Diagora 公司信函如附件。7 月 21 日起處理僑居地及子女入學問題等私事完全自費與公務無關，本人於 7 月 31 日回到台灣。

二、國外差旅心得

1. 目前哥大在等交大 的機器人完成後才能進行臨床試驗，而交大 的研發因受學生不足等因素影響，進度落後甚多，是台灣團隊需加強的地方。

2. 哥倫比亞大學 Prof. Hasselgren 向聯邦政府申請研究經費的補助未能成功，現在只由臨床實習診所的收入負擔部分開銷。

3. University of Cincinnati 的 Prof. Dong 有從州政府及學校取得小額經費，仍須努力。

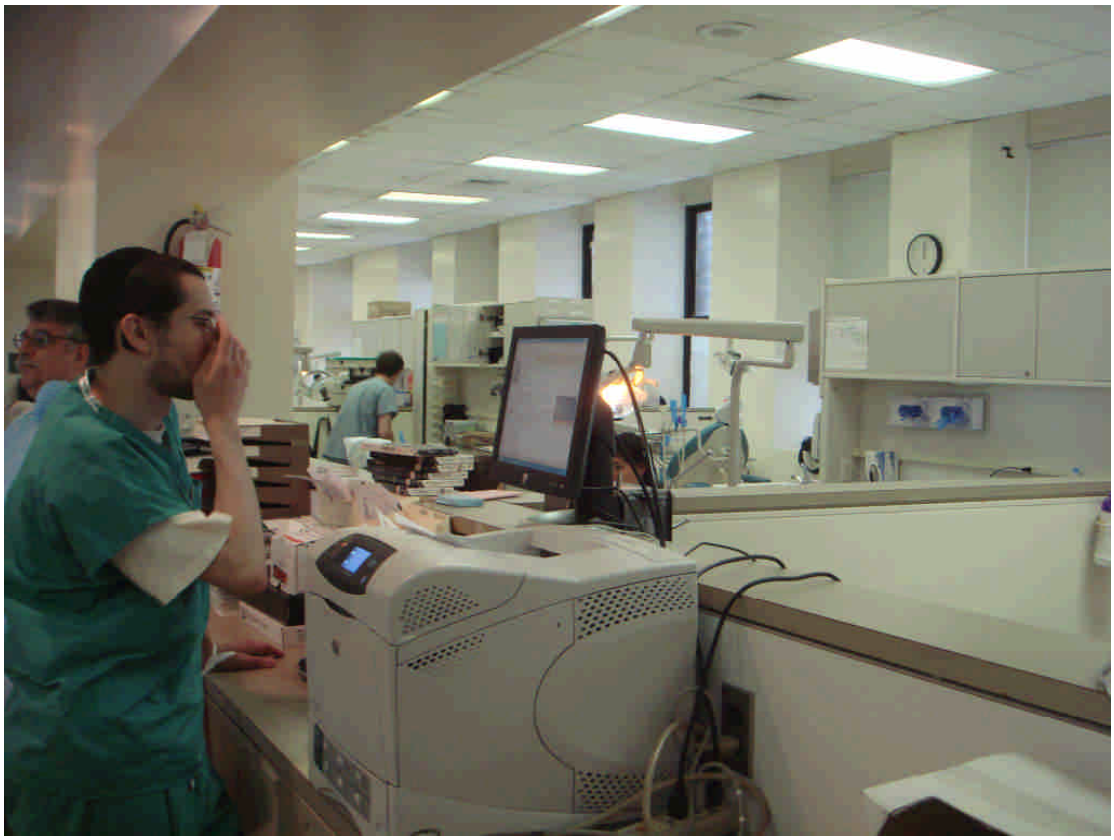
4. 為了繼續計畫的進行,從國外的牙醫器材製造商取得適當的資源還是有需要，因此三方聯名的信函希望能帶來希望。

出國人員　洪錫源

國立交通大學機械系 教授

在哥大牙醫學院門口留影

我們的合作夥伴 Professor Gunnar Hasselgren



在哥倫比亞大學附設醫院牙醫實習診所進行討論

Soredex
Nahkelantie 160
PO Box 148
FI 04301 Tuusula
Finland

Dear Sir or Madam;

During root canal treatment the clinician is dependent on radiographic images for information regarding anatomy, working length during cleaning and shaping of the canal(s), and for quality check of final root filling etc. As radiographs are 2-dimensional images of 3-dimensional objects it would be a great help for the dentist to see a 3-dimensional image of the tooth and the root canal(s) prior to treatment. 3-dimensional radiography is not new, but it requires special equipment.

We are a group that has worked on the idea of obtaining a 3-dimensional image without for example tomography: Dr Shane Hong is a former professor of Mechanical Engineering at Columbia University and National Chiao Tung University (Taiwan), Dr Janet Dong is a professor of Mechanical Engineering at the University of Cincinnatti, and Dr Gunnar Hasselgren is a professor of Endodontics at Columbia University. We have developed a method to obtain a 3-dimensional computer image of root canals based on two regular, 2-dimensional, radiographic images. This gives the dentist an opportunity to see a 3-dimensional image of the inner dental anatomy before entering the root canal and without requiring expensive extra equipment. The reason for contacting you is to find out if you would be interested in discussing this as an addition to the Digora system.

Sincerely

Gunnar Hasselgren DDS, PhD Janet Dong PhD Shane Hong PhD

國科會補助專題研究計畫項下出席國際學術會議心得報告

日期：99 年 10 月 31 日

計畫編號	NSC96 － 2221 － E － 009 － 147 － MY2		
計畫名稱	先進牙髓病根管治療專用精密機器人之發展		
出國人員姓名	洪錫源	服務機構及職稱	國立交通大學機械系 教授
會議時間	99 年 2 月 7 日至 99 年 2 月 10 日	會議地點	Houston, Texas, USA
會議名稱	ASME2010 奈米工程在醫學及生物應用第一次全球國際會議 與哥大及辛辛那提大學合作團隊討論國合計畫技術進展 ASME 2010 First Global Congress on NanoEngineering for Medicine and Biology		
發表論文題目	（英文）Design of Z Axis Acutator & Quick Tool ChangeAssembly for an Endodontic Micro Robot		

一、參加會議經過

本人於 2010.2.2.離台於 2 月 4 日抵美國辛辛那提大學先與國際計畫合作人 Janet Dong 教授討論計畫進行現況，2 月 7 日抵達休士頓參加 ASME 奈米工程在生醫應用會議三天，2 月 10 日在返台

旅途中飛經紐約市與哥倫比亞大學牙醫學院 Gunnar Hesselgren 教授討論計畫進行狀況，於 2 月 12 日回到台灣。

二、與會心得

在會議主題的領域裡，其涵蓋有下列子主題做為會議分區:1. NanoEngineering for medical diagnostics; 2.Nanoengineering for medical therapeutics and imaging; 3.Nano/Micro fluidics for medical diagnostics and therapeutics; 4. NanoEngineering for regenerative medicine; 5. Manufacturing and materials for nanomedicine; 6. Multiscale modeling in biological systems; 7. Biological nanomechanics. 這些子領域對台灣的學術界還很新，由於投入設備經費與人才匯集不易，宜加入休士頓大學團隊而後分出題目帶回台灣進行。會議中的 Panel discussion 由四位諾貝爾獎得主和與會人士交流經驗，感覺受益良多。有攜回會議彙編的技術論文集的光碟片，有興趣者可借閱。

三、考察參觀活動(無是項活動者略)　　無

四、建議

1. 休士頓大學的奈米工程在醫學應用團隊堅強先進，國內應派人去學習。
2. 國內跨領域研究之團隊組合應予鼓勵與加強。

五、攜回資料名稱及內容

Proceedings of ASME 2010 First Global Congress on NanoEngineering for

Medicine and Biology

六、其他

分別拜訪本計劃的國際合作夥伴，紐約市的哥倫比亞大學與牙醫學院系主任的哈索格蘭教授，與辛辛那提大學的董家驤教授向他簡報目前計畫最新進展，展示我們所做的機器人零件組合。兩人亦將來台回訪。

國科會國際合作計畫出差心得報告

計畫編號: NSC96－2221－E－009－147－MY2

計畫名稱:先進牙髓病根管治療專用精密機器人之發展
出差日期: 98 年 7 月 15 日至 99 年 7 月 20 日

出差地點: 美國**紐約市哥倫比亞大學牙醫學院**

出差目的: 與哥大及辛辛那提大學合作團隊討論國合計畫技術進展

一、國外差旅經過

本人於 98 年 7 月 15 日從新竹出發，7 月 16 日到達紐約，稍事休息，於當地 7 月 17 日星期四在哥倫比亞大學牙醫學院(照片 1)與我們的國際合作夥伴，該校的牙隨科系主任的哈索格蘭教授(照片 2)以及他的研究及臨床團隊見面(照片 3)，向他簡報目前計畫最新進展，展示我們所做的機器人零件組合，並邀請他來台回訪。隔天 7 月 18 日星期五 Dr. Hasselgren 帶我進入哥大附設醫院 Vanderbilt Clinic of Dental School, 實地探討目前牙醫病患根管治療實例，並試驗我們所發展的先進牙髓病根管治療專用精密機器人在臨床上可能遭遇的問題。7 月 20 日星期日美國不上班，但是 Prof. Janet Dong, University of Cincinnati 從 Ohio 趕來紐約因此三方面聚首討論整個計畫的未來方向，並草擬給 Diagora 公司信函如附件。7 月 21 日起處理僑居地及子女入學問題等私事完全自費與公務無關，本人於 7 月 31 日回到台灣。

二、國外差旅心得

1. 目前哥大在等交大 的機器人完成後才能進行臨床試驗，而交大 的研發因受學生不足等因素影響，進度落後甚多，是台灣團隊需加強的地方。

2. 哥倫比亞大學 Prof. Hasselgren 向聯邦政府申請研究經費的補助未能成功，現在只由臨床實習診所的收入負擔部分開銷。

3. University of Cincinnati 的 Prof. Dong 有從州政府及學校取得小額經費，仍須努力。

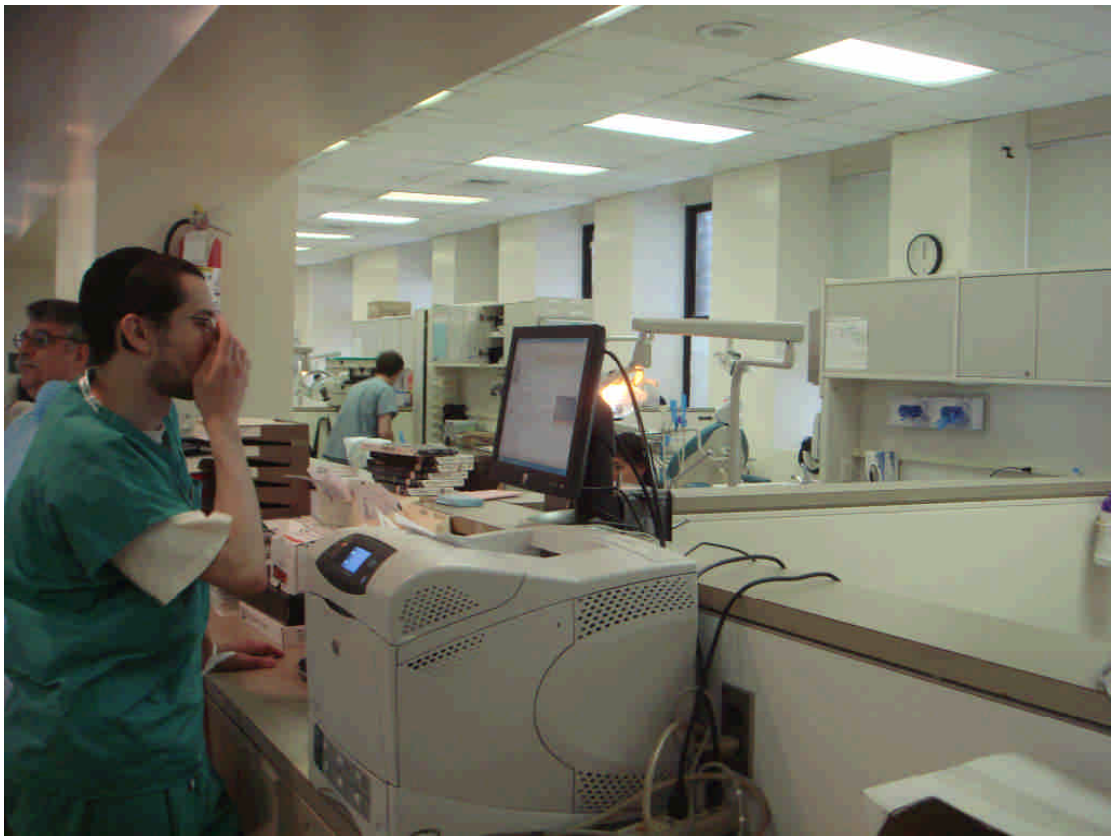
4. 為了繼續計畫的進行,從國外的牙醫器材製造商取得適當的資源還是有需要，因此三方聯名的信函希望能帶來希望。

出國人員　洪錫源

國立交通大學機械系 教授

在哥大牙醫學院門口留影

我們的合作夥伴 Professor Gunnar Hasselgren



在哥倫比亞大學附設醫院牙醫實習診所進行討論

Soredex
Nahkelantie 160
PO Box 148
FI 04301 Tuusula
Finland

Dear Sir or Madam;

During root canal treatment the clinician is dependent on radiographic images for information regarding anatomy, working length during cleaning and shaping of the canal(s), and for quality check of final root filling etc. As radiographs are 2-dimensional images of 3-dimensional objects it would be a great help for the dentist to see a 3-dimensional image of the tooth and the root canal(s) prior to treatment. 3-dimensional radiography is not new, but it requires special equipment.

We are a group that has worked on the idea of obtaining a 3-dimensional image without for example tomography: Dr Shane Hong is a former professor of Mechanical Engineering at Columbia University and National Chiao Tung University (Taiwan), Dr Janet Dong is a professor of Mechanical Engineering at the University of Cincinnatti, and Dr Gunnar Hasselgren is a professor of Endodontics at Columbia University. We have developed a method to obtain a 3-dimensional computer image of root canals based on two regular, 2-dimensional, radiographic images. This gives the dentist an opportunity to see a 3-dimensional image of the inner dental anatomy before entering the root canal and without requiring expensive extra equipment. The reason for contacting you is to find out if you would be interested in discussing this as an addition to the Digora system.

Sincerely

Gunnar Hasselgren DDS, PhD Janet Dong PhD Shane Hong PhD

國科會補助計畫衍生研發成果推廣資料表

日期:2010/11/06

國科會補助計畫	計畫名稱: 先進牙髓病根管治療專用精密機器人之發展
	計畫主持人: 洪錫源
	計畫編號: 96-2221-E-009-147-MY2　　學門領域: 產業機械

無研發成果推廣資料

96 年度專題研究計畫研究成果彙整表

計畫主持人：洪錫源	計畫編號：96-2221-E-009-147-MY2
計畫名稱：先進牙髓病根管治療專用精密機器人之發展	

成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數(含實際已達成數)	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	1	0	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	7	0	100%	人次	
		博士生	1	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
國外	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	1	0	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)	1.本計畫有國際合作共同主持人 Prof. Gunnar Hesselgren, Columbia University 及Prof. Janet Dong, University of Cincinnati。 2.不管在國內或在國外學術討論會中發表論文,此計畫總得到與會學者的熱烈討論,本計畫所代表的技術創新至為顯著。若能成功發展，將是工程科學對醫療技術的一大貢獻。

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

□達成目標

■未達成目標（請說明，以 100 字為限）

□實驗失敗

□因故實驗中斷

■其他原因

說明：

因為職場鬥爭, 遭人陷害蒙羞, 中途被解聘, 復職後又被阻擾收研究生, 致計畫進行以借用其他教授學生支援, 計畫尚未完成, 經費尚餘甚多, 容後繼續完成.

2. 研究成果在學術期刊發表或申請專利等情形：

論文：■已發表 □未發表之文稿 □撰寫中 □無

專利：□已獲得 □申請中 ■無

技轉：□已技轉 ■洽談中 □無

其他：（以 100 字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以 500 字為限）

不管在國內或在國外學術討論會中發表論文, 此計畫總得到與會學者的熱烈討論, 本計畫所代表的技術創新至為顯著。若能成功發展，將是工程科學對醫療技術的一大貢獻。