



**UNIVERSITY OF ALBERTA**

**ORTHODONTIC GRADUATE PROGRAM**

**Department of Dentistry**

**Faculty of Medicine and Dentistry**

**Strategic Business Plan**

**2008/2009**

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## I. ALIGNMENT WITH THE UNIVERSITY VISION

The University of Alberta vision states: *To inspire the human spirit through outstanding achievements in learning, discovery, and citizenship in a creative community, building one of the world's great universities for the public good*". The four "cornerstones" to anchor this vision are: *talented people; learning, discovery, and citizenship; connecting communities; and transformative organization and support*.

The University of Alberta mission states: *Within a vibrant and supportive learning environment, the University of Alberta discovers, disseminates, and applies new knowledge through teaching and learning, research and creative activity, community involvement, and partnerships. The University of Alberta gives a national and international voice to innovation in our province, taking a leadership role in placing Canada at the global forefront*".

This Strategic Business Plan 2008/2009 supports the vision and mission of the University of Alberta. It provides the foundation for the academic, clinical and research initiatives planned to attain the specific vision and mission of the University of Alberta Orthodontic Graduate Program. This plan builds on the academic, clinical and research success already achieved.

Key elements of the Orthodontic Graduate Program which support the University of Alberta vision include:

### Talented People

- Intentional recruitment of graduate students from around the world. As of September 2008, the program will have 12 MSc and 5 PhD (all foreign) contributing to the global perspective and intercultural climate. Each year we have approximately 60 qualified applicants for the MSc and 10 applicants for the PhD program.
- Outstanding and diverse full time academic staff able to provide a spectrum of clinical and research expertise. Full-time and Part-time affiliate academic staff provide residents with clinical, didactic and research mentorship
- Supportive and goal oriented non-academic staff are provided with opportunities for career development. We currently have 20 non-academic support staff.
- Collaborative research opportunities for visiting scholars ongoing

### Learning, Discovery and Leadership

- The Program is committed to providing a positive combined structured and self-directed learning environment
- Residents have opportunity to participate in rotations through the Orofacial Pain Clinic, Cleft Lip and Palate Clinic and Maxillofacial Surgery Clinic
- Seminars are structured to enhance literature review and information assimilation skills. Where appropriate, students will be assigned to lead seminars with the academic staff member providing direction for group discussion.
- The Program is committed to increasing the awareness and interest of the residents to the lack of evidence-based clinical practices. (cultural shift, new graduates with critical thinking skills and understanding of systematic reviews).
- Research education is an integral part of the program. Students gain the skills necessary for publication in peer reviewed scientific journals and experience in research presentation.
- Students may participate in cross disciplinary course work and research projects.
- Students are encouraged to accept leadership roles in student bodies within the University and within the professional community.
- The Orthodontic Graduate Program has a formal research and teaching collaboration with Dresden University in Germany. This involves funded research initiatives as well as the potential for student exchanges.

- Cross-disciplinary collaborative research teams (Pharmacy, Mechanical Engineering, Chemical and Materials Engineering, Biomedical Engineering and Computing Science) are established in conjunction with the operating plan to develop long-term research projects suitable for major external funding.
- Focus is on developing grant competitive research program with collaboration across U of A Faculties and with other universities. Key research focus areas include: 3D assessment of craniofacial form, research focused on Bioengineering / Biomechanics / Biomaterials.
- Involvement of undergraduate students in research and patient care being conducted within the Orthodontic Graduate program. PhD students in particular will serve as academic role models for undergraduate students.
- Our team has published approximately 72 peer reviewed scientific papers over the last 3 years.
- Due to the impressive publication record of the Orthodontic Graduate Program, the Program has gained international prominence

#### Connecting Communities

- The Orthodontic Graduate Program Chapter of the University of Alberta Alumni Association (OAA) was formed in 2003. The OAA membership includes most of our alumni as well as the majority of Alberta orthodontists. There is a student representation on the OAA executive and the OAA have taken an active role in student interviews, organizing social events directed at integration of our students into the professional community, fund raising and offering learning opportunities.
- Each year industry donates over \$300,000 in clinical supplies (gifts-in-kind) to support clinical education.
- High quality orthodontic treatment is provided for approximately 400 new patients each year
- Treatment fees are set at approximately 60% of private practice fees providing financially viable access for lower income families from the greater Edmonton and surrounding areas.
- The Program works in cooperation with Cleft Lip and Palate Clinic to manage the specialized orthodontics needs of the Cleft Lip and/or palate patients.
- Interaction with the private practice community through formal “externship” program enriches the resident’s experience and provides an outreach professional continuing education opportunity
- The Orthodontic Graduate Program offers continuing education opportunities to the regional Orthodontic Community for an ongoing development of professional partnerships

#### Transformative Organization and Support

- The Orthodontic Program has two endowment funds. The McIntyre Memorial Fund (\$928,000) was established in 1986 to support research within the Orthodontic Graduate Program. The Gerry Boychuk Memorial Fund (\$120,000) was established in 2005 to support patient orthodontic health education.
- American Association of Orthodontics Foundation has awarded two \$15,000 salary supplements for the period July 1<sup>st</sup>, 2007 to June 30<sup>th</sup>, 2008 to aid development of two junior academic faculty members.
- 3D imaging research has been significantly enhanced with the recent donation of a NewTom CT scanner (\$300,000) in 2004 and an iCat cone beam CT (\$185,000) in 2008.
- The Canadian Commission on Dental Education completed full accreditation of the U of A Orthodontic Graduate Program in March 2007. Graduates are eligible for national examinations (in Canada this is the Royal Canadian Dental College) leading to licensure in Canada and United States as a certified specialist in orthodontics.
- Residents are exposed to, and train in, the Orthodontic Graduate Clinic which operates utilizing entrepreneurial and private practice management, models and principals providing exposure to new technologies, contemporary evidence-based procedures and practice management skills.

## II. ASSUMPTIONS

The University of Alberta Orthodontic Graduate Program is uniquely positioned to aggressively move forward as an internationally recognized education and research program. In developing this plan the following key assumptions have been made:

- The “trust account” under which the clinical operation has been administered has been transitioned to an “operating account”. The clinical operation will continue to be administered by the Program Director under supervision of the Chair, Department of Dentistry.
- The current level of program support from the Department will continue.
  - University salary support for three tenure stream academic positions.
  - Continuation of the current clinical, administrative and research space allocation.
- There is an adequate patient pool in the Edmonton area for operation of the clinical facility.
- Continued support by the local orthodontic professional community and increased involvement of the Orthodontic Alumni Association.
- There will continue to be an adequate pool of qualified applicants for the MSc and PhD programs.

### III. INTRODUCTION

#### 3.1 Vision

“Graduate orthodontically qualified clinical scientists by encouraging intellectual curiosity and lifelong learning for the benefit of their communities”. This will be based on excellence in evidence-based clinical education, focused externally funded collaborative research, and leadership in the adoption of innovations leading to improved patient care.

#### 3.2 Mission

“The University of Alberta Orthodontic Graduate Program is committed to providing academic and clinical experience for successful educational or scientifically based private practice careers. We will create an environment that promotes innovation and critical thinking skills with participation in leading edge research and implementation of evidence-based clinical procedures into practice. Through a self-directed learning environment we will establish the foundation for our graduates to be leaders in their professional and local communities. We will serve our regional orthodontic community and alumni by providing advanced learning opportunities. We will serve our local community by providing quality orthodontic care to a segment of the population not able to access private practice.”

#### 3.3 Values

The U of A Orthodontic Graduate Program core values are:

- Respect: for our academic and clinical faculty, students, patients, support staff, our professional community and for each other
- Progressive: in both the human and technical areas of our organization. We are committed to a team-based environment; leading edge evidence-based clinical practices and state-of-the-art technology. We encourage academic curiosity that extends into clinical practice.
- Excellence: in all that we do. We are committed to delivering quality patient care, preparation of our students for successful specialty orthodontic practice as evidence-based clinicians, preparation of selected students for successful academic careers, generation of clinically relevant research and transference of new knowledge to the orthodontic profession

#### 3.4 Core Activities

##### Teaching

- MSc – Provides the education leading to certification in the dental specialty of orthodontics, participation in collaborative clinical research and implementation of new knowledge into clinical practice
  - 3 to 4 students accepted per year
  - 36 month program
- PhD - Provides the education leading to certification in the dental specialty of orthodontics. Research experiences are available in clinical or foundational sciences with teaching experience necessary for an academic career path
  - Up to 1 student accepted per year
  - Usually a 60-72 month program

### Clinical Service

- High quality orthodontic treatment is provided for approximately 400 new patients each year. With treatment fees set at approximately 60% of private practice fees, a financially viable access for lower income families is provided
- Newly renovated state-of-the-art clinical facility operating on private practice model with integration of new technologies into clinical practice

### Research

- Currently developing a focused grant competitive research program with collaboration across U of A Faculties and with other universities. Key research focus areas include: 3D assessment of craniofacial form, research focused on Bioengineering / Biomechanics / Biomaterials.
- Collaborative research opportunities for visiting scholars

#### **IV. RECOGNIZED AREAS OF EXCELLENCE**

##### Education:

The University of Alberta Orthodontic Graduate Program has a long-standing national reputation for excellent clinical education in clinical orthodontics. The program offers a variety of current clinical techniques and seeks to integrate new knowledge into clinical practice. Critical thinking skills necessary for pursuing evidence-based practice are emphasized and the ultimate goal of the program is to develop clinical scientists with the ability to conduct private practice based research.

##### Clinical:

The clinical operation of the Orthodontic Graduate Program operates on a cost neutral basis with its own budget, which allows integration of private practice management principals in an entrepreneurial environment. Without financial risk to the University, the clinic has the flexibility to allow integration of new technologies and application of newly developed patient care techniques. Furthermore, students are provided an opportunity to experience the business model utilized in highly successful contemporary private practices. The Canadian Association of Orthodontists has selected the "Alberta Model" as a model for clinical organization within a university and the American Association of Orthodontists has expressed interest in details from our unique clinical structure.

##### Research:

The Orthodontic Graduate Program has developed a strong publication history with approximately 130 peer reviewed scientific papers over the past 10 years. Most graduate student thesis research results in submission for publication and in many cases several multiple publications per thesis are achieved. In the 2007-2008 period 36 papers were published in peer reviewed scientific journals. The publication record of the Orthodontic Graduate Program has gained international prominence.

The recent introduction of a combined PhD/Orthodontics program and the research focus outlined in this strategic plan will create the environment and culture necessary to achieve our vision and mission.

## V. FORCES AND SOURCES OF CHANGE

### 5.1 Description and Outlook

- Orthodontics represents dentistry's oldest recognized graduate level specialty program. There are currently four English and one French program in Canada, accepting a total of 19 students per year. There is a very competitive applicant pool with approximately 20 academically qualified applications for each available position.
- Throughout Canada and the United States there is increasing demand for Orthodontic specialists. The Canadian Orthodontic Association and American Orthodontic Association have identified a future "manpower" crisis with increasing population, increased demand for orthodontic care within the population.
- The combination of very good private practice career opportunities with increased income disparity between private practice and academic salary, combined with increased student debt loads has also led to a crisis in recruitment and retention of qualified academic staff. Traditional graduate orthodontic programs do not provide suitable educational opportunities to pursue an academic career.
- The University of Alberta Orthodontic Graduate Program was founded in 1970. In 1988 the Program was changed from a Diploma to a MSc format. The program has graduated 85 students.
- As a component of the 1996 restructuring of Dentistry as a Department in a combined Faculty of Medicine and Dentistry, the Orthodontic Graduate clinic began operating as a cost centre (trust account). Operating under the name "Orthodontics 2001" the clinic was a financial success.
- With the installation of Dr. Paul Major as the Director of the Orthodontic Graduate Program in July 2001, a new strategic plan for the Orthodontic Graduate Program was developed. The Strategic Plan called for extensive facility renovation, initiation of a PhD/Orthodontics program and Faculty commitment to recruit two additional full-time tenure track academics to support the Orthodontic Graduate Program. University Administration endorsed the Strategic Plan.
- An extensive (\$543,000) facility renovation was completed in December 2002. The renovation was financed by a University grant and funds from Orthodontic Clinic revenues. Administrative support space for faculty and student offices has also been developed. Private donations (\$91,450) provided furnishings and equipment upgrades.

### 5.2 Key Elements of SWOT Analysis

#### Strengths

- Internal collaborations have been established (Pharmacy, Mechanical Engineering, Chemical and Materials Engineering, Biomedical Engineering, Radiology and Diagnostic Imaging, Computing Science). These collaborations have resulted in three cross appointments, external research funding and cross discipline PhD and MSc student research supervision. External collaborations have also been established with Universities in Germany and Saudi Arabia. A strong and integrated research focus for the Orthodontic Graduate Program has been established.
- Strong financial position provides the potential to be financially innovative in support of Graduate Orthodontics (e.g. salary supplements, research funding). This includes a unique endowment fund that provides approximately \$85,000 annually (McIntyre Fund) for support of research.
- Culture and vision supportive of innovation and change exists at all levels within the University to facilitate success for this Graduate Program.
- Recent recruitment of highly qualified full-time academic staff.
- State of the art bioengineering research lab to support program research has been allocated. A 3D craniofacial imaging lab is currently being developed utilizing cone beam CT imaging and stereophotogrametry.

- The implementation of the combined PhD/Orthodontics program will provide research trained orthodontic professionals. Through our PhD program, Post-Doctoral Fellowship and junior academic mentoring program we are actively addressing the need for Orthodontic educators.

#### Weaknesses

- Orthodontics and TMD/Orofacial Pain are the only clinical specialty programs offered in the Department of Dentistry. This limits the number of graduate students in the Department and limits opportunity for orthodontic graduate students to interact with other clinical dentistry disciplines. The overall emphasis of the Department of Dentistry is on pre-doctoral training.

#### Opportunities

- There is a need for research trained dental professionals (e.g. clinical scientists, academics) across Canada and the US, and interest by CIHR, AHFMR, and other government agencies to address this deficiency. This creates opportunities for graduates and others interested in participating in research in some role.
- There is an increasing emphasis on collaborative research team models by funding agencies.
- A strong provincial economy that supports technological developments (3D imaging & modeling, nanotechnology, tissue engineering) together with an increasing awareness of the need for innovative models that facilitate transfer to clinical practice. In Alberta, there is an emphasis on technology transfer from the private sector to Universities and vice versa.
- Increasing awareness and interest in the lack of evidence-based clinical practices (cultural shift, new graduates with critical thinking skills and systematic reviews).
- Our international relationships provide opportunities for international transfer of knowledge and University of Alberta recognition.
- We have opportunity to train and mentor clinically qualified academics to faculty positions throughout the world.

#### Threats

- Low number of research grants awarded to dentistry in comparison with medicine (due to a low level of applications and the fact that applications are too narrow in scope). Perceptions of orthodontic research in comparison with major health issues, is a disadvantage.
- Significant income disparity between dental practice and research/academic careers.

### 5.3 Regulatory

- The Canadian Commission on Dental Education completed full accreditation of the U of A Orthodontic Graduate Program in March 2007. Full accreditation has been granted until 2014. Graduates are eligible for national examinations leading to licensure in Canada and United States as a certified specialist in orthodontics.

## VI. ACADEMIC PLAN

### 6.1 Introduction

The Department of Dentistry will continue to offer Graduate courses and clinical experience leading to a MSc in Clinical Dentistry (Orthodontics). This program will provide the educational experience to allow eligibility to write the Royal College of Dentists of Canada and American Board of Orthodontics examinations as one of the processes for specialist certification in orthodontics. The objective of this program is to provide the academic and clinical experience for a successful private practice career. The student will also gain the research experience to participate in collaborative research projects and transfer new knowledge into clinical practice.

The Department has also introduced a PhD in Medical Sciences (Orthodontics) program, providing advanced research and teaching training in addition to the education necessary for the clinical Specialty of Orthodontics. These students will complete the same clinical courses as MSc students with additional courses as necessary for their research and teaching. The objective of this program is to provide the academic and clinical experience for a successful private practice and/or academic career. Two distinct research programs have been identified leading to different academic career opportunities. The clinical researcher track will provide the student with the skills necessary to plan and participate in funded collaborative clinical research programs. Students pursuing this career path will spend approximately 40-60% of their time in research with the balance being spent in clinical and teaching activity. The clinical scientist track will focus on foundational research leading to post-doctoral training and ultimately a career as primary investigator of a nationally funded research program. These individuals will spend approximately 80% of their time in research with minor clinical activity.

### 6.2 Program Philosophy

The University of Alberta Orthodontic Graduate Program is committed to providing a positive structured but self-directed learning environment. Full-time and part-time affiliate Academic staff offer students clinical, didactic and research mentorship.

Our clinical program is organized based on a contemporary private practice patient care delivery model. Modern technologies and current evidence-based treatment modalities are utilized. Junior, intermediate and senior residents are organized as functional teams and are expected to work together in treatment planning and patient care delivery. Senior residents provide clinical mentoring for junior and intermediate residents with overall supervision by academic staff. To enhance clinical experience students have opportunity to participate in rotations through the Orofacial Pain Clinic, Cleft Lip and Palate Clinic, Maxillofacial Surgery Clinic and “off campus” approved private practice locations.

Seminars are structured to enhance literature review and information assimilation skills. Where appropriate, students will be assigned to lead seminars with the academic staff member providing direction for group discussion. Our program encourages orthodontists from the private practice community to participate in seminars. Interaction with the private practice community enriches the student experience and provides an outreach professional continuing education opportunity.

Research education is an integral part of the program. Students will gain the skills necessary for publication in peer reviewed scientific journals and experience in research presentation.

### 6.3 Program Description

Our program offers students the choice of combining clinical orthodontic education with an MSc or PhD Graduate degree. MSc and PhD students will participate together in Orthodontic lectures and seminars.

#### MSc

The three-year MSc program provides the academic and clinical experience for a successful private practice career. Program completion will further depend on completion of program requirements including; course work, clinical case completion, presentation of research findings at scientific meetings and submission for publication in peer reviewed journals.

The following courses are currently offered:

- OBIOL 500 (Oral Biology I) – (3-0-0)  
Functional anatomy of head and neck. Development, structure, function, and biochemistry of connective tissue associated with the jaws.
- OBIOL 501 (Oral Biology II) - (3-0-0)  
A continuation of Oral Biology I. Growth and development of skull. Anthropology. Selected topics in physiology.
- DENT 530 (Orthodontic Techniques and Biomechanics) – (3-0-3)  
Biomechanics and its application in clinical orthodontics
- DENT 531 (Advanced Orthodontic Biomechanics) – (3-0-0)
- DENT 532 (Growth and Development) - (2-0-0)  
A detailed review of the postnatal growth and development of human craniofacial structures. Longitudinal and cross sectional growth data are presented.
- DENT 540 (Orthodontic Seminars) - (0-6-0)  
Selected orthodontically related theoretical and practical topics along with orthodontic case management presentations are discussed in both seminar and preclinical formats.
- DENT 541 (Orthodontic Clinics) - variable hours  
Applied clinical education and experience is obtained through supervised management of selected orthodontic cases.
- DENT 551 (Introduction to Applied Statistics) - (3-0-2)  
Analysis of variance, multiple linear regressions, measures of association and agreement, logistic regression, and non-parametric methods. Topics will also include sample size calculation, power analysis, and a brief introduction to meta-analysis. The concepts will be motivated by problems in the dental and medical sciences. Application to real data will be emphasized through the use of SPSS and Splus.
- DENT 552 (Applied Multivariate Statistical Analysis) - (3-0-2)  
Multivariate analysis of variance, repeated measures, multivariate linear regression, principal components, discriminate analysis, cluster analysis, and multidimensional scaling will be studied. Topics will include shape analysis in three dimensions. The concepts will be illustrated by problems in dentistry and medical sciences. Each student will submit a written report and present a research project focusing on these statistical methods.
- DENT 562 (TMD/Orofacial Pain Seminars) - (0-2-0)  
Seminars in the diagnosis and treatment of temporomandibular joint problems. Includes a comprehensive literature review. Emphasis placed on orthodontic considerations in the prevention and management of mandibular dysfunction. (Course is optional for Orthodontic students and is offered in alternate years).
- DENT 565 (Evidence-Based Dentistry) - (2-0-0)  
This course is designed to review the general principles of evidence-based dentistry. Expertise will be gained in the search, evaluation and use of evidence in clinical situations.
- DENT 566 (Systematic Reviews in Dentistry) – (2-0-0)

This course is designed to review the general principals of systematic reviews and meta-analysis. Students will gain the skills necessary to publish and/or interpret systematic reviews in peer reviewed journals.

- DENT 640 (Orthodontic Seminars) - (0-6-0)  
Second year seminar and preclinical presentations. Requires successful completion of DENT 540.
- DENT 641 (Orthodontic Clinics) – variable hours  
Second year applied clinical educational program. Requires successful completion of DENT 541.
- DENT 740 (Orthodontic Seminars) - (0-6-0)  
Third year seminar and preclinical presentations. Requires successful completion of DENT 640
- DENT 741 (Orthodontic Clinics) - variable hours  
Third year applied clinical educational program. Requires successful completion of DENT 641.

#### Clinical Outcome Assessment:

The first outcome-based assessment is completed at the end of the first year. Full time academic staff will assign students three sets of orthodontic case records to diagnose and treatment plan. This will be followed by an oral examination.

The second outcome-based assessment will be conducted at the end of the second year. Students will be required to present three cases (initial and progress records). The format will follow RCDC format and utilize the RCDC case selection criteria. Full time academic staff will conduct the examination.

The final outcome assessment will occur in March or April of third year with an external examiner. Students will present full case analysis utilizing the RCDC format on three treated cases utilizing the RCDC case selection criteria. The students undergo an oral examination utilizing the RCDC format. Feedback from this assessment will serve to identify weak areas in the student's progress that will permit the development of specific improvement objectives before the next annual assessment. Failure to overcome the limitations will require the student to extend their program to allow for remediation.

## PhD

The PhD/Orthodontics program provides the academic and clinical experience for a successful private practice or academic career. Students enrolled in the PhD program will not have the option of transferring to the MSc in Orthodontics program but they could transfer to the MSc in Dentistry as an option without orthodontic clinical training. The program will be structured to meet the individual educational objectives of the student. For students conducting clinical research, the clinical training will be integrated through the program based on the individual student's research project. For students conducting basic science research, most of the research will be completed and the student will have passed the candidacy examination before starting clinical training. The thesis supervisory committee will determine what milestones will need to be met prior to beginning the clinical portion of the program.

PhD students will complete a major research project equipping graduates with the expertise to conduct grant competitive research of international prominence. To support the development of an academic career, the final two years of the PhD program will include Undergraduate and Graduate teaching.

The following courses are offered:

- OBIOL 500 (Oral Biology I) - (3-0-0)  
Functional anatomy of head and neck. Development, structure, function, and biochemistry of connective tissue associated with the jaws.
- OBIOL 501 (Oral Biology II) - (3-0-0)  
A continuation of Oral Biology I. Growth and development of skull. Anthropology. Selected topics in physiology.
- DENT 530 (Orthodontic Techniques and Biomechanics) – (3-0-3)  
Biomechanics and its application in clinical orthodontics
- DENT 531 (Advanced Orthodontic Biomechanics) – (3-0-0)
- DENT 532 (Growth and Development) - (2-0-0)  
A detailed review of the postnatal growth and development of human craniofacial structures. Longitudinal and cross sectional growth data are presented.

- DENT 540 (Orthodontic Seminars) - (0-6-0)  
Selected orthodontic related theoretical and practical topics along with orthodontic case management presentations are discussed in both seminar and preclinical formats.
- DENT 541 (Orthodontic Clinics) - variable hours  
Applied clinical education and experience is obtained through supervised management of selected orthodontic cases.
- DENT 551 (Introduction to Applied Statistics) - (0-3-2)  
Analysis of variance, multiple linear regressions, measures of association and agreement, logistic regression, and non-parametric methods. Topics will also include sample size calculation, power analysis, and a brief introduction to meta-analysis. The concepts will be motivated by problems in the dental and medical sciences. Application to real data will be emphasized through the use of SPSS and Splus.
- DENT 552 (Applied Multivariate Statistical Analysis) - (0-3-2)  
Multivariate analysis of variance, repeated measures, multivariate linear regression, principal components, discriminate analysis, cluster analysis, and multidimensional scaling will be studied. Topics will include shape analysis in three dimensions. The concepts will be illustrated by problems in dentistry and medical sciences. Each student will submit a written report and present a research project focusing on these statistical methods.
- DENT 562 (TMD/Orofacial Pain Seminars) - (0-2-0)  
Seminars in the diagnosis and treatment of temporomandibular joint problems. Includes a comprehensive literature review. Emphasis placed on orthodontic considerations in the prevention and management of mandibular dysfunction.
- DENT 565 (Evidence-Based Dentistry) - (2-0-0)  
This course is designed to review the general principles of evidence-based dentistry. Expertise will be gained in the search, evaluation and use of evidence in clinical situations.
- DENT 566 (Systematic Reviews in Dentistry) – (2-0-0)  
This course is designed to review the general principals of systematic reviews and meta-analysis. Students will gain the skills necessary to publish and interpret systematic reviews in peer reviewed journals.
- DENT 640 (Orthodontic Seminars) - (0-6-0)  
Second year seminar and preclinical presentations. Requires successful completion of DENT 540.
- DENT 641 (Orthodontic Clinics) - variable hours  
Second year applied clinical educational program. Requires successful completion of DENT 541.
- DENT 740 (Orthodontic Seminars) - (0-6-0)  
Third year seminar and preclinical presentations. Requires successful completion of DENT 640
- DENT 741 (Orthodontic Clinics) - variable hours  
Third year applied clinical educational program. Requires successful completion of DENT 641.

Additional courses related to specific area of research may be required.

Students will be required to participate in teaching courses offered through University of Alberta Teaching Services and demonstrate lecture and clinical teaching effectiveness.

#### Clinical Outcome Assessment:

The first outcomes-based assessment is completed at the end of the first clinical year. Full time academic staff will assign students three sets of orthodontic case records to diagnose and treatment plan. This will be followed by an oral examination.

The second outcomes-based assessment will be conducted at the end of the second clinical year. Students will be required to present three cases (initial and progress records). The format will follow RCDC format and utilize the RCDC case selection criteria. Full time academic staff will conduct the examination.

The final outcome assessment will occur in March or April of third clinical year with an external examiner. Students will present full case analysis utilizing the RCDC format on three treated cases utilizing the RCDC case selection criteria. The students undergo an oral examination utilizing the RCDC format.

Feedback from this assessment will serve to identify weak areas in the student's progress that will permit the development of specific improvement objectives before the next annual assessment. Failure to overcome the limitations will require the student to extend their program to allow for remediation.

### **Orthodontic Seminars**

- Orthodontic seminars are provided to cover the range of orthodontic topics not included in other numbered courses. The seminar series will vary as some topics will be adequately covered by students attending "off campus" scientific meetings and by "on campus" guest speakers. Seminars will be offered on a rotating basis so students participate as a large group.

## 6.4 Staffing

Academic success depends on quality academic and non-academic support staff.

### **Tenure Track Academic**

The Department will support three full-time tenure track orthodontic academic positions.

#### 1. Program Director

##### Responsibilities

- Organize and execute the educational, research and administrative components of the program
- Develop and implement the curriculum
- Document the instructional content of the program to ensure accreditation standards and the instructional objectives of the program are met
- Document and evaluate student participation in the didactic and clinical programs, and document that the results have been discussed with the student
- Coordinate the teaching activities of faculty assigned to the program
- Administer clinic operations including budgeting and finances
- Coordinate student selection
- Ensure collaboration on research and teaching initiatives across North America, involving leading orthodontic programs
- Develop strategic research alliances with industry and research collaboration with other University of Alberta departments and with other Universities
- Seek external funding to support research initiatives

##### Qualifications

- Fellow of the Royal College of Dentists of Canada (orthodontics)
- Demonstrated administrative experience in coordinating a graduate clinical teaching program, staff supervision and financial management
- Demonstrated experience in graduate student clinical and didactic teaching.
- Demonstrated research ability with a significant publication record

#### 2. Clinical Academic

##### Responsibilities

- Primary commitment to didactic and clinical teaching in the Orthodontic Graduate Program
- Secondary commitment to teaching in the undergraduate dentistry program
- Conduct and publish original research supporting the research focus of the program
- If possible seek external funding to support research initiatives
- Graduate student research supervision

Qualifications

- PhD or MSc (Orthodontics) with a strong research and publication record
- Demonstrated experience in graduate level clinical and didactic teaching
- Graduate student thesis supervision experience

3. Research Academic

This position may be filled with a non-clinician who has expertise in the research focus of the Orthodontic Program. The position may also be filled with two individuals with cross appointments in other departments where their primary research supports the focus of the Orthodontic Graduate Program.

Responsibilities

- Primary commitment to obtain external research funding to support the research focus of the Orthodontic Graduate Program
- Graduate student research supervision

Qualifications

- PhD with a strong interest in collaborative research and graduate level teaching

Whenever required, recruitment of academic staff will be achieved through offering competitive financial compensation, participation in a well organized and successful research program and access to research seed funding. Working in a research environment with funded PhD and post doctoral students provides for excellent productivity. A carefully planned and coordinated research program will allow the development of key areas of research focus. Collaboration will improve competitiveness for external research funding and the Alberta Heritage Foundation for Medical Research provides unique grant opportunities. Full-time academic staff will have the opportunity to participate in extramural private practice to maintain clinical skills and supplement their incomes.

**Affiliate Academic**

Certified specialists in orthodontics from the private practice community will contribute to orthodontic seminar and clinical teaching. Utilization of qualified private practice professionals provides students with experience in treatment philosophies and techniques used in contemporary private practice. Non-tenure track academic positions could be supported by program clinic revenue.

Clinic scheduling is designed to provide continuity of patient care while allowing flexibility for affiliate academic staff. Two academic/affiliate staff with compatible treatment philosophy and mechanics will co-supervise a group of cases if possible. This approach allows reduced individual time commitment and the affiliate staff members can work out their own schedule for clinical supervision.

**Support Academic**

The Department will financially support and assist arrangements for teaching support in related dental disciplines such as oral biology.

### **Non-academic Support**

Sufficient dental auxiliary personnel will be available to provide efficient patient care based on a private practice patient care delivery model. Dental auxiliary personnel will be supported through program clinic revenue. The Department will provide an administrative assistant to support the academic staff.

#### 6.5 Student Research

Students will be required to complete research within the established research focus of the program and complete a paper format thesis. Students are expected to submit their research results to peer reviewed journals for publication and have their research presented at an international scientific meeting. It is anticipated that most student research projects will result in publication.

#### 6.6 Student Selection

Students will have completed an undergraduate dentistry program and meet the eligibility requirements established by the Faculty of Graduate Studies and Research. Applications for the MSc in Medical Sciences (Orthodontics) and PhD in Medical Sciences (Orthodontics) will be received and reviewed by the full-time academic Orthodontic staff. Suitable candidates will be interviewed and rank ordered. The interview committee will include all full-time Orthodontic Academic staff, a current orthodontic graduate student, a part-time Affiliate Academic staff or representative from the Orthodontic Alumni/Mentorship Association and a clinical support staff.

MSc and PhD candidates chosen by the interview committee will be recommended to the Department of Dentistry, Director of Graduate Studies and Research for provisional acceptance. Admission will be dependent upon the recommendation of the Medical Sciences Committee and final approval from FGSR.

Recruitment of PhD candidates is not anticipated to be a significant problem. We receive approximately 10 qualified applications for the PhD/Orthodontics program. There is tremendous need for a program that offers combined clinical, advanced research and teaching training for individuals seeking an academic career. The Canadian Association of Orthodontists and the American Association of Orthodontists have identified recruitment and retention of Orthodontic Faculty as a major concern.

#### 6.7 Student Finances

The approximate cost of the three-year MSc program is \$25,000 over three years. This includes tuition, books and professional supplies. The cost increases for foreign students as determined by FGSR.

PhD students may be provided with a living stipend. This stipend will be achieved by government sponsorship, application for support from the AAOF, Alberta Heritage Foundation for Medical Research and Graduate Student Teaching Assistantships. Additional funding may be provided from clinical revenues, if available and as required, to reach a minimum \$36,000 stipend. To obtain stipend funding through clinic revenues, the student must demonstrate that all other funding avenues have been exhausted.

The approximate cost of the program is \$35,000 over five years. This includes tuition, books, and professional supplies. The cost increases for foreign students as determined by FGSR.

## VII CLINICAL OPERATIONS

### 7.1 Background

The Faculty of Dentistry began operating an Orthodontic Graduate Clinic in 1970 under the general faculty budget. As a component of the 1996 restructuring of Dentistry as a Department in a combined Faculty of Medicine and Dentistry, the orthodontic clinic began operating as a cost centre (trust account). Operating under the name, Orthodontics 2001, the clinic was a financial success. A third MSc student was added, and in keeping with a private practice model, support staff was increased to allow increased patient load. In 2002 a detailed strategic business plan was introduced and the clinic continues to be a financial success. Since 2006 four MSc students are usually admitted.

This strategic plan builds on the strengths of the existing programs and will allow enhancement of Orthodontic Graduate Student education and research.

### 7.2 Basis of Financial Projections

These financial projections have been prepared to facilitate strategic planning for the Orthodontic Graduate Program. Successful implementation of academic and research initiatives will depend on financial resources made available through clinic revenue.

These projections have been prepared using assumptions that reflect the planned course of action for the period covered. Significant assumptions used in preparation of these projections are described.

In May 2007 the Trust Account was transitioned to an Operating Account.

The effective date for the assumptions was October 31, 2008. For the purpose of planning, March 31 was used for year-end. New students start each year at the beginning of September (fall term).

As of March 31, 2008 the Orthodontics Graduate Trust Account had a negative cash balance of \$220,000. The negative cash balance was the result of a large outstanding accounts receivable.

7.3 Orthodontic Graduate Clinic Operating Budget 2008-2009

	Actual Mar-Sept	Total Budget
<b>Revenue</b>		
Accounts receivable at March 31, 2008	-220,000	-220,000
Fees	760,849	1,820,367
Misc	16,606	20,000
	<u>557,455</u>	<u>1,620,367</u>
<b>Salary Expenses</b>		
Administrative Assistant	5,330	30,716
Treatment Coordinator	35,974	71,779
Patient Coordinator	29,330	58,727
Receptionist	60,989	126,254
Clinical Support ICS	21,879	48,606
Part-time Academic	14,182	45,587
Tarek El-Bialy	22,856	48,463
Carlos Flores-Mir	60,421	122,335
Carlos Flores-Mir Supplement Pay (PP)	37,385	87,536
RDA	175,635	352,990
Lab Technicians	84,526	164,616
PhD Student Stipend	47,324	56,788
Contract for Services	622	17,000
Research Associate		18,000
Research Assistant	49,659	94,672
	<u>646,113</u>	<u>1,344,068</u>
<b>Variable Expenses</b>		
Lab Supplies	1,355	9,102
Clinical Supplies	49,887	109,222
Front Office Expenses	10,139	27,305
Credit Card Fees/Commissions	4,367	12,743
Bad Debt	11,021	86,000
Staff Development	1,623	3,000
Computing Expenses	2,651	6,000
Academic Travel Expenses	468	3,000
Repairs & Equipment Maint	6,959	10,000
Other	3,164	10,922
Special Projects	763	1,500
Clinical Research transfer		55,890
	<u>92,396</u>	<u>334,684</u>
<b>Education Enhancement</b>		
Student Travel / Scientific Meetings	19,211	25,000
Guest Lectures		1,500
	<u>19,211</u>	<u>26,500</u>
<b>Total Expenses</b>		
	<u>757,719</u>	<u>1,705,253</u>
Anticipated Accounts Receivable at year end		85,000
<b>Net Income</b>	<u>-200,264</u>	<u>114</u>

## 7.4 Significant Assumptions

### a. Students

For the fall term 2007 four MSc students and one PhD student were accepted. For the fall term 2008 four MSc were accepted. The PhD student will do course work and thesis related research for two additional years before entering clinical training.

### b. Fee Revenue

Fee revenue is generated from patients requiring orthodontic treatment. Fees are based on approximately 60% of private practice fees as follows:

Examination	\$50
Diagnostic records	\$320
Conventional treatment	\$4200
Phase I (mixed dentition) treatment	\$1200
Complex treatment (RPE, impacted canines)	\$4900
Surgical treatment and cleft palate	\$5300

Payment of the treatment fee will be designed to meet patient needs, but will generally be paid in 24 equal monthly payments. Phase I treatment is comprised of 6 equal monthly. The diagnostic records and initial exam fees are paid in full prior to commencement of treatment.

### c. Patients

For the term beginning in September 2008, the clinic will initiate 308 comprehensive and 40 Phase I treatment cases. No new cases will be started after the first year, but students will continue to provide treatment until completion of their final term. Most cases will be finished by the same student but complex cases not completed will be transferred to a second year student for continuation.

Patients will commence treatment during the months of September through April and conventional treatment will normally require 24-28 months to complete. Complex treatment will take approximately 30-36 months to complete.

PhD students will participate in clinic for three years. Students conducting clinical research will begin clinical training in their first year. Students doing fundamental (basic science related) research will begin clinical training after their PhD candidacy examination.

Patient care provided by full time academic staff will be phased out with no new patient starts after September 2008. Sixty percent of the fee for active treatment being provided by academic staff will be considered supplementary practice income and will be paid every two months. The remaining 40% will be retained in the clinic to cover overhead expenses.

Clinical trial research is conducted in the Orthodontic Graduate Clinic. These projects are approved by the University of Alberta Human Research Ethics Board and are being supervised by full time academic faculty. 40% of collected fee revenue for these patients is retained in the Orthodontic Graduate Program Operating Account to cover overhead costs and the remaining 60% is transferred to the Research Trust Account of the principal investigator of the related clinical trial research.

d. Donations

Orthodontic supply companies traditionally donate some of their products for use in Canadian Orthodontic Graduate Programs. The volume of orthodontic supplies used is directly related to clinic activity. Recent discussions with the major orthodontic supply companies have confirmed ongoing support.

e. Fixed Expenses

Clinical space will continue to be provided rent-free by the Department. Fixed expenses are comprised of salaries and benefits.

The following positions are currently filled and are expected to continue:

- Administrative Assistant
- Receptionists
- Clinical Support ICS
- Treatment coordinator
- Patient Coordinator
- Research Assistant/TA
- Dental assistants
- Laboratory technicians
- PhD student stipends

The University will supply salary support for three tenure track full-time academic staff. These positions are currently filled. To aid in recruitment and retention a market supplement of \$20,000/year for one junior tenure-track clinical academic staff will be provided through clinic revenue. A second tenure-stream academic position is being funded through clinical revenue.

Affiliate part-time Academic staff will be required on the following basis:

- Clinical Instruction (approximately \$150/half day)
- Preclinical Lecture / Treatment planning seminar / Instructional Seminars (\$75/hour)

Note: Each clinically qualified full-time academic staff will provide one half day/week clinic instruction and one preclinical lecture. To maintain quality clinical instruction with increased number of students and increased patient flow, two instructors will be in clinic at the same time. The effective instructor/student ratio is 7:1.

One new PhD student will be provided \$36,000 annual stipend living stipend from clinical revenue each of the five years. Two PhD students have stipend scholarship from their government. The remaining three PhD students have completed the clinical training portion of their education and are no longer being provided with stipends

f. Variable Expenses

Variable expenses are projected based on previous management experience in the Graduate clinic and in private practice. These expenses are calculated as a percentage of gross clinical fee revenue using the following formula:

- Laboratory supplies and contract plaster orthodontic study model preparation (0.5% of fee revenue)
- Clinical supplies (6.0% of fee revenue)
- Front office expenses (includes postage, stationery, printing, subscriptions, computing supplies, photocopying, telephone and courier) (1.5% of fee revenue)
- Credit card fees/commissions (0.7% of fee revenue)
- Bad debt  
During the 2007-2008 year accounts receivable dramatically increased (\$220,000 at March 31). This was carried forward as a “debt” into the current year. In September, the issue of accounts receivable was identified as a major concern. Steps have been taken to resolve outstanding accounts receivable and to develop protocols to avoid recurrence of this problem. A significant write off of bad debt (\$75,000) is anticipated. The expected carry forward accounts receivable at the end of March 2009 is expected to be approximately \$85,000
- Staff Development (team building, sponsored courses for non academic staff)
- Computing expenses (software upgrades, software maintenance contracts)  
To remain at the leading edge of orthodontic management technology \$6,000/annum is budgeted.
- Academic Travel (travel expenses for part-time academic staff living in Calgary, for out-of-town seminar presenters).
- Other (includes postage, advertising and promotion) (0.6% of fee revenue)

Special Projects will include costs associated with implementation of the strategic plan. In the 2008-2009 year special projects will include three special events; student graduation event in June, student welcome event in September and the “Ortho Advocate” newsletter. The budget for special projects in the 2008-2009 year is \$1,500.

g. Education Enhancement

Funds are allocated to enhance student education as follows:

- Student Travel  
\$25,000 is allotted for travel to scientific meetings and for tuition costs. This amount will be used to cover meeting expenses for students presenting meaningful papers or posters in the meetings. Educational opportunities identified by the program directors as having major educational benefit may be funded. Students are expected to present thesis research at least one IADR meeting.
- Guest Lectures  
\$1,500 is budgeted for International Guest Lectures. It is anticipated most guest lecturers will receive Alberta Heritage Foundation grants or expenses will be covered through continuing education revenues.

h. Space requirements

The existing facility is adequate.

i. Inflation:

Salary expenses for 2008-2009 reflect the NASA collective bargaining agreement.

## VIII RESEARCH PLAN

The Orthodontic Graduate Program at the University of Alberta is uniquely positioned to become a leader in orthodontic research. We are establishing a focused approach with short- and long-term strategies in order to achieve “Centre of Excellence” status. We have defined our key research goals with the intent to take advantage of current opportunities, minimize the impact of potential threats, capitalize on our internal strengths and overcome weaknesses.

### 8.1 Biomechanics Orthodontic Research Group

The “Biomechanics Orthodontics Research Group” is a joint endeavour between Dr. Paul Major (Department of Dentistry) and Drs. Toogood and Carey (Department of Mechanical Engineering). Dr. Major’s role is to guide the overall research program and to provide clinical expertise. Dr. Carey guides the biomechanics aspect of the work and Dr. Toogood provides technical equipment design expertise. This interdisciplinary collaboration has led to one of the most dynamic biomechanics/design oriented research partnerships in Canada as evidenced by the number of publications, presentations at scientific meetings and training of highly qualified personal in both disciplines. A number of collaborators are and will continue to be involved in components of the research. For their expertise in reconstruction, Drs. Boulanger, Cheng and Basu (Department of Computing Science), for expertise in statistics Dr. Heo (Department of Dentistry), for expertise in measurement of material deformation Dr. Noble (Department of Mechanical Engineering) and for clinical orthodontics Dr. Flores-Mir (Department of Dentistry) will participate.

The research group continues to focus in four key areas, namely, the analysis and prediction of complex force systems; the development and validation of 3D reconstruction images (CBCT, laser scanning and stereophotogrammetry) of the orofacial complex used for diagnosis and treatment planning in orthodontics; development and testing of new maxillary expansion devices and patient specific finite element modeling of orthodontic treatments.

#### *a. Analysis and prediction of complex orthodontic force systems*

Force systems can be defined as statically complex determinate or indeterminate. Determinate force systems in orthodontics are those in which a couple is created at one attachment with only a force (no couple) at the other attachment. An example would be a wire attached to a tube or bracket on one end with only a point of contact on the other end. In most cases orthodontic force systems involve attachment of a tube or wire at both ends, creating an indeterminate force system. Analysis of indeterminate force systems is very difficult and becomes increasingly complex as more attachments are added. When non-linear biologic response of the periodontal ligament and surrounding bone is added the force systems become so complex to analyze using the laws of static equilibrium.

We have designed and constructed an orthodontic simulations system (OSIM) that will allow measurement of 3D forces and moments simultaneously on all 14 teeth engaged in an orthodontic appliance such as an archwire. The teeth are positioned and oriented independently to simulate a broad range of malocclusions. The instrument calibration and validation is complete and data is being gathered to analyze the force propagation with vertically positioned cuspids and horizontally displaced incisors.

An analytic FEM model of the 14 tooth system will be developed. The objective of the analytic model is to correctly predict the forces acting on each tooth for a specified malocclusion and treatment plan. The model will incorporate the non-linear material behaviours, friction (binding) within the bracket/wire interface and periodontal

ligament compliance. The analytic model will be verified by comparison with experimental data obtained from the OSIM. Once validated, such a system will allow clinicians to “engineer” patient specific force systems in orthodontic treatment.

An experimental device has also been designed and constructed to measure in-situ deformation and stress induced on an orthodontic bracket when load is applied through a torque wire. The imaging system consists of a CCD camera, a set of long distance high magnification imaging optics and an illumination source. The orthodontic bracket is illuminated in an epifluorescent manner and reflected light is imaged onto the CCD camera. The high resolution camera collects images at known positions of applied torque and the images are downloaded to a PC via a high speed interface for processing. Images are then converted to a quantitative measurement of displacement by performing a cross-correlation between successive images. The images are broken into sub-regions and the cross-correlation is performed generating a correlation map for each sub-region. A peak detection algorithm is then used to determine the maximum correlation peak within the data. The distance and direction from the centre of the correlation is a direct measurement of the displacement vector, which is then converted into a stress measurement.

Preliminary data is now being gathered for titanium and stainless steel orthodontic brackets. The strain applied with the torque force is measured with a 3D force transducer. CAD drawings for the brackets and physical properties of the brackets and wire have been obtained from the manufacture and are being used to generate a finite element model (FEM). The observed bracket deformation and scalar map of stress components measured with our optical device are being compared with the theoretical FEM model.

Knowing the bracket deformation properties will allow the clinician to use the ideal wire/bracket combination to achieve desired tooth movement. It will also allow application of engineering principals in development of new bracket designs for use in industry.

b. *Development and validation of 3D reconstructed images of the craniofacial complex*

The objective of this work is to move toward global acceptance and use of 3D reconstructed images by the orthodontic community to assess treatment needs, evaluate treatment outcome and evaluate craniofacial growth. This will involve development and validation of methods to quantify craniofacial form, development and validation of reference systems to identify changes in craniofacial form over time and integration of 3D data sets acquired by Cone Beam CT (CBCT), photogrammetry (3dMD) and laser surface scanning. Normative data will need to be gathered to describe deviations of a particular individual from normal or desired state.

To date, a standardization method consisting of a reference point and plane orientation has been developed and published. Accuracy of CBCT has been established and published. Density (HU) conversion factors for the NewTom CBCT for use in FEM models have also been calculated and published. Dr. Flores-Mir is now working on a method for superimposition of craniofacial hard tissue images from the CBCT, with soft tissue surface contours obtained by the 3d MD and surface laser scanning devices. This will require development of synchronization and superimposition software.

Combining the imaging systems with patient specific FEM is exciting future work. Prediction of treatment and how a patient might look after treatment will be an incredible advance in patient care.

c. *Development and testing of a new-bone borne maxillary expansion device*

The primary objective is the design and development of a bone-borne orthodontic expansion device capable of achieving orthopedic change in the maxilla without unwanted tooth movement. The device is now undergoing a randomized clinical trial with a PhD student in Orthodontics.

External funding has been obtained to conduct a parallel collaborative study with Dr Harzer at Dresden University in Germany. This project will involve a randomized clinical trial of a different bone-borne

expansion device and will be conducted in Dresden, Germany and in Edmonton. Recruitment for this study began in September 2007.

The maxillary expansion trials will provide a test sample to use in refining the 3D imaging techniques described in Section b. Palatal expansion involves change in maxillary dimensions, tooth positions (relative to the maxilla and mandibular teeth) and nasal airway. These are complex objects and will provide an excellent model to evaluate the utility of our 3D imaging techniques.

In addition to measuring the skeletal and dental effects of tooth borne versus bone anchored expansion, we are utilizing acoustic rhinometry to assess nasal airway changes associated with maxillary expansion. Obstructive sleep apnea is a major medical concern in young patients. Typically these patients have a narrow constricted maxilla and nasal airway insufficiency. Preliminary results suggest that bone anchored maxillary expansion creates more orthopedic change than conventional expansion. Collaboration has been initiated with Dr. El-Hakim (pediatric ENT) and Dr. Witmans (pediatric pulmonologist) to investigate this area further. The nasal airway has very complex geometry and 3D segmentation of the airway from cone beam volumetric imaging (CBCT) is a very time consuming process and is not feasible for large patient samples. We are working with Dr. Cheng (computer science) to test algorithms for automated segmentation of the airway. Once the airway has been effectively segmented into a volumetric data set, air passage can be modeled using the principals of fluid dynamics. The shape of the airway is likely more important than the size of the airway for normal function. This knowledge will be extended to analysis of other treatment interventions and study of factors influencing craniofacial growth.

d. *Development of patient specific FEM*

The long range objective is to develop a tool that the clinician could use to accurately predict the outcome of a treatment for any specific patient from the 3D imaging system. Our group has completed preliminary models of the bone-borne maxillary expansion device. This has involved determining bone density from CBCT using a dry skull, segmenting and generating bone structures from the CBCT images and using secondary software

8.2 Statistical Shape and Sequential Analysis of Multidimensional Data

Dr. Giseon Heo (Bio-Statistics) has been recruited to the Orthodontic Graduate Program to develop this research initiative.

High-dimensional data, such as digital images, molecular structures, and sensor networks, are termed point cloud data (PCD). In most medical studies, the measurements taken from the patients are also multi-dimensional and time dependent.

It is difficult to visualize and capture the true features of objects in high dimension. It also complicates mathematical and statistical analyses. Dr. Heo's research topics are threefold:

- a. Dimension reduction of PCD mathematically, capturing true lower-dimensional features and easing visualization and statistical interpretation.
- b. Shape analysis. Recently, topologists have come up with computational techniques of extracting the topological and geometrical features of PCD. Dr. Heo is currently learning the topologists' approach and trying to combine their results with statistics.
- c. Sequential analysis. It is desirable to stop a clinical trial as soon as significant evidence is collected. Group and fully sequential analyses are useful for this purpose.

Dr. Heo's overall research goal is to enhance multivariate statistical techniques by applying methods from computational topology.

### 8.3 Tissue Engineering Research

- a. *Development and testing of an intra-oral ultrasound device for treatment of orthodontic induced root resorption.*

Dr. El-Bialy's collaboration with Electrical Engineering has resulted in NSERC grant support for this project. Once the device has been developed and tested, a clinical trial to study the effects of therapeutic ultrasound on root resorption associated with different types of orthodontic tooth movement will be conducted. Also, this device will be used for tooth root healing after traumatic fracture and replantation in dogs.

Collaboration with University of Toronto has been established to study the effect of therapeutic ultrasound on stem cell expansion and differentiation for craniofacial tissue engineering.

Tissue engineering of the articular condyle for TMJ biological replacement is underway. Preliminary studies showed positive in-vivo integration and a large scale study is proposed.

The use of stem cell based periodontal tissue repair including cementum and dentine is underway. Also, discovering new pluripotent cells and their clinical use in dental/periodontal tissue repair and tissue engineering is being documented.

### 8.4 Evidence Based Orthodontics

Dr. Flores-Mir has established the "Cranio-facial and Oral-Health Evidence-Based Practice Group" within the Orthodontic Graduate Program to promote evidence-based dentistry and in particular evidence-based orthodontics. More than 15 systematic reviews have already been published by members of the orthodontic graduate program and several more have been accepted for publication. The topics of these systematic reviews are mostly related to clinical orthodontics but some have also analyzed public health issues (xerostomia), TMD (head posture and TMD), dentistry diagnostic processes (electromyography). Several others are under development.