"Our comprehensive approach in pediatric oral and maxillofacial surgery has made **a world of difference** for children with rare and complex disease and structural deformities."

Leonard B. Kaban, DMD, MD

Since 1994, **Leonard B. Kaban, DMD, MD**, has served as the Walter C. Guralnick Professor at Harvard Medical School and chairman of the Department of Oral and Maxillofacial Surgery at Massachusetts General Hospital.

Dr. Kaban is actively engaged in research in the fields of cranio-maxillofacial distraction osteogenesis, minimally invasive surgery, jaw tumors in children and craniofacial anomalies. He has an ongoing interest in fetal wound healing, and has conducted numerous clinical studies involving distraction, reconstructive surgery and orthognathic surgery. Dr. Kaban has authored or co-authored more than 225 scientific articles and five books, including a new edition of the text *Pediatric Oral and Maxillofacial Surgery* with co-editor and colleague **Maria J. Troulis, DDS, MSc**.

Dr. Troulis joined the Massachusetts General Hospital Department of Oral and Maxillofacial Surgery in 1999. She is an associate professor of Oral and Maxillofacial Surgery at Harvard Medical School and director of the Minimally Invasive Surgery Program, as well as director of the Skeletal Biology Research Center. Dr. Troulis's primary clinical interests are pediatric oral and maxillofacial surgery, reconstructive surgery and orthognathic surgery.

Dr. Kaban and Dr. Troulis collaborate to solve clinical problems.

Saving face: improving outcomes in pediatric oral and maxillofacial surgery

The Massachusetts General Hospital Department of Oral and Maxillofacial Surgery was established nearly 140 years ago, with the founding of the Harvard Dental School. Since those early days, the department has broadened its scope and grown in size and stature to become one of the most widely respected oral and maxillofacial surgery services in the world.

Under the leadership of Leonard B. Kaban, DMD, MD, the department provides a full breadth of cutting-edge clinical services to both children and adults, and offers a combined oral surgery/MD residency program, as well as a pediatric fellowship. The department also conducts a diverse program of innovative basic and clinical research that has significantly improved outcomes for children with often-complex and/or rare congenital and acquired oral and maxillofacial conditions.

In 1996, Dr. Kaban established the Skeletal Biology Research Center within the department. Now under the direction of Maria J. Troulis, DDS, MSc, this multidisciplinary center focuses on developmental skeletal biology, with projects under way in many diverse areas, including distraction osteogenesis, tissue engineering, jaw tumors and minimally invasive surgical techniques. "Although our research is eclectic, we have a single goal: to decrease morbidity for patients," explains Dr. Troulis. As described below, significant progress is being made toward this goal.

In recent years, oral and maxillofacial surgeons at Massachusetts General Hospital and elsewhere have developed minimally invasive techniques to correct many facial soft-tissue and skeletal deformities, which have resulted in less overall morbidity, decreased pain and swelling and faster recovery.

According to Dr. Kaban, approximately 85 percent of pediatric patients who undergo mandibular reconstructive procedures require skeletal expansion. Traditionally, this has been achieved with bone grafts or soft-tissue flaps harvested from a donor site—typically the patient's hip, chest, ribs or skull. This entails a second operation, increased operating room and anesthesia time, and often significant donor-site morbidity.

The traditional approach poses other problems, as well. For example, in children who may require large quantities of bone, there may be inadequate bone to harvest from one site, requiring multiple donor sites. In addition, bone resorption is unpredictable, which may result in an undesired loss of volume. "Because of these drawbacks, we are actively seeking novel ways to create new bone to avoid donor-site harvesting," explains Dr. Kaban.

Distraction osteogenesis

One effective approach is distraction osteogenesis (DO), which entails the gradual lengthening of bone by placing tension forces across an osteotomy using specialized devices.

Among those who are likely candidates for this procedure are children with micrognathia, which is characterized by a very small lower jaw and, in severe cases, life-threatening airway obstruction requiring a tracheostomy. Children with midface hyperplasia, such as cleft lip/palate, or more severe syndromes of midface hypoplasia, such as Cruozon or Apert syndrome, are also potential candidates, as are children with acquired conditions resulting from trauma, tumor resection or radiation therapy.

In properly selected patients, DO offers many advantages. It not only avoids donor-site morbidity, but it also can be performed using minimally invasive techniques, sometimes endoscopically. For children with micrognathia, DO also permits the jaw to be moved greater distances than can be achieved with the conventional approach. Moreover, in early studies, the newly created bone appears to be more stable.

According to Drs. Kaban and Troulis, the Skeletal Biology Research Center is focused on several areas relating to DO. These include studying the biology of bone-wound healing and muscle response, minimally invasive access, distractor device design and 3-D treatment planning.

Most current DO devices are external—attached to the face with pins. The Skeletal Biology Research Center has developed a novel, semi-buried, miniature distraction device that, unlike earlier devices, is capable of accurate 3-D movements along a curvilinear path. In

partnership with industry, the center now has several grants to develop a totally buried device that will be driven by a micromotor and move automatically along a 3-D curvilinear path. These devices will be integrated with a 3-D treatment-planning system developed by the Skeletal Biology Research Center using software developed in the Harvard Surgical Planning Laboratory. "In the future, this will be a powerful tool for skeletal expansion in the craniomaxillofacial region," notes Dr. Kaban.

Tissue engineering

Another major focus of the Skeletal Biology Research Center is tissue engineering. The goal of tissue engineering is to create permanent, living tissue that functions normally and can be used for implantation, thereby eliminating donor-site morbidity and the need for replacement organs.

In collaboration with the Massachusetts General Hospital Tissue Engineering and Organ Fabrication Laboratory, led by MassGeneral Hospital for Children Surgeon-in-Chief Joseph P. Vacanti, MD, the Skeletal Biology Research Center recently successfully created a tissue-engineered mandibular condyle.

While tissue-engineered bone has been created from allogeneic or xenogeneic cells, this is one of the first examples in the field of oral and maxillofacial surgery of the creation of a tissue-engineered bone using autologous cells, which, due to immunologic issues, is closer to the proposed use of fabricated bone in the clinical setting.

Dr. Troulis and her colleagues are currently focusing on addressing the dual challenges of achieving tissue vascularization and greater bone penetration throughout the biodegradable scaffold on which the tissue forms. Their long-term goal is to tissue engineer a mandibular growth center. "In the future, the marriage of endoscopic exposure and surgical techniques with tissue-engineered bone will make it possible to correct congenital and acquired craniomaxillofacial skeletal deformities with no donor-site morbidity, at low cost, and with a minimal hospital stay," predicts Dr. Troulis, who is leading this initiative.

Antiangiogenic therapy for jaw tumors

Another innovation introduced by the Department of Oral and Maxillofacial Surgery—a novel, minimally invasive treatment regimen for aggressive giant cell lesions of the jaws—has had a dramatic impact on the outcomes of young pediatric patients, in whom these lesions tend to occur.

Aggressive lesions are locally invasive and destructive, and have a very high recurrence rate. Standard treatment has been wide, en bloc resection and reconstruction of the bone and soft tissue defect. Occasionally, radiation therapy has been used for refractory lesions, but this can be severely disfiguring if administered during a period of rapid facial growth.

Seeking a less draconian treatment, Dr. Kaban hypothesized that these tumors were proliferative vascular lesions and, as such, would be expected to respond to antiangiogenic therapy with interferon. In a small cohort of patients, Dr. Kaban and his colleagues evaluated a novel protocol that entailed a minimally invasive procedure consisting of enucleation of the tumor, taking care to preserve the teeth and inferior alveolar nerve, followed by antiangiogenic therapy with interferon.

This protocol was first published in the journal *Pediatrics* in 1999 and then in the *Journal of Oral and Maxillofacial Surgery* in 2002. The initial series consisted of eight patients, seven of whom completed the entire protocol. There were no recurrences of tumor after two years. Interestingly, in some patients the enucleated bone defect regenerated much more quickly than would have been expected, and half the mandible completely regenerated in one child, which suggests that interferon may also stimulate bone formation. The department currently has 30 patients enrolled in a larger, ongoing prospective study. Although the recurrence rate for this lesion is historically between 30-60 percent, none of these patients has had a recurrence.

Since its founding in 1867, the Department of Oral and Maxillofacial Surgery has been committed to improving outcomes for children with oral and maxillofacial conditions. As these projects demonstrate, the department has made major strides toward achieving this important goal. ■