Many dental schools offer implant clinical training at the pre- and postdoctoral levels, but little has been published on the clinical outcomes of implants placed in those programs. A post-entry chart review was conducted of all Branemark and Taper-Lock implants placed in a university clinic by faculty-student teams. Case information was gathered on data reporting forms and entered into a computer spreadsheet program. Survival rates were calculated as percentages. Cumulative implant survival was 96% for all 303 implants placed. Eight of the 12 implants that failed were placed by 2 operators, only 1 of whom was in the early stages of implant training. Branemark implant survival was 94.9% (n = 198) at 36 months; failures occurred between stage 2 and 3 months (n = 8) in mandibles and after 12 months (n = 2) in maxillae. Taper-Lock implant survival was 98.1% (n = 105) at 24 months; no mandibular failures occurred, but maxillary failures occurred before stage 2 (n = 1) and after 12 months of loading (n = 1). Taper-Lock implants exhibited a slightly higher (3.2%) cumulative survival rate at 24 months compared to Branemark implants. Differences in the numbers of implants placed (105 vs 198) and follow-up times (24 months vs 36 months) may have skewed the comparative results of Taper-Lock and Branemark implants, respectively, in this study. Implant survival for both systems was similar at 24 months of follow-up, and clinician experience did not appear to be an influencing variable on implant survival.
despite a 73% increase in the number of implant practitioners from 1986 to 1990. In 1998, a survey of practicing dentists in the United States reported slightly declining participation in implant dentistry by general practitioners compared to a significant increase by prosthodontists, and cited differences in the levels of implant education as a possible cause. A 10-year survey of US dental school graduates reported that those who had hands-on clinical and/or laboratory experience with implant dentistry at the predoctoral level were significantly more likely to incorporate implant dentistry into their dental practices than students with no formal, hands-on education.

Despite these findings, dental schools have been slow to implement implant-training programs into their curricula. In the United States, the number of dental schools that required implant-related lectures rose from 20% in 1974 to 89% by 1990, and some had implemented clinical experience at both the pre- and postdoctoral levels. Internationally, a 1995 survey of 51 dental schools reported that 86% had incorporated similar programs into their predoctoral curricula, and many of those in industrialized nations also offered opportunities for clinical and laboratory participation by students. Although the number of implant training programs at the university level continues to grow, little has been published about the survival of implants placed in such programs.

An investigation into the clinical outcome of implants placed in university training programs would be of general clinical interest in view of reports in the dental literature that prior surgical experience with dental implants may be an influencing variable on implant survival at stage 2.

Hebrew University–Hadassah School of Dental Medicine in Jerusalem, Israel, conducts a clinical implant training program through the Oral Implant Center of Hadassah Medical Center. Sponsored by the departments of Oral and Maxillofacial Surgery, Periodontics, and Prosthodontics, students gain valuable, hands-on experience through participation in faculty-student treatment teams.

This article is a retrospective clinical review of screw-design implants from 2 manufacturers placed in the Oral Implant Center by faculty-student teams with different experience levels.

### Materials and Methods

#### Study parameters and data analysis

The study population consisted of patients treated for partial or complete edentulism with implants placed and restored by faculty-student teams in the Oral Implant Center. Treatment with Branemark (Nobel Biocare, Yorba Linda, Calif) and/or Taper-Lock (Zimmer Dental, Carlsbad, Calif) implants was the sole criterion for inclusion in the study. All patients who met this criterion were included in the study, and no other inclusion/exclusion criteria were used.

A list of patients who met this criterion was generated from the university’s database, and post-entry chart reviews were conducted for all patients. Case information from each chart was gathered on data collection forms and subsequently entered into a spreadsheet program (Microsoft Excel 2002, Microsoft Corp, Redmond, Wash) on a personal computer. The entered data were validated for accuracy and analyzed by the investigators of this study. In addition, questionnaires were sent to all referring clinicians whose patients did not return for routine prophylaxis and annual follow-up.

The primary objective of this investigation was to determine cumulative implant survival for all Branemark and Taper-Lock implants placed in the Oral Implant Center by faculty-student treatment teams. Secondary objectives of this study were to determine (1) if there was a difference in survival rates between the Branemark and Taper-Lock implants, and (2) if prior clinical experience was an influencing variable on short-term implant survival. In this study, implant survival was evaluated according to 6 clinical criteria (Table 1).

#### Clinical procedures

A detailed diagnostic work-up was completed for each patient by faculty-student treatment teams. Health histories and oral examinations were performed to assess current health status, the volume of available bone, and the presence of any undiagnosed diseases or pathologies that required treatment before implant placement. In addition to panoramic radiographs, computerized tomographic (CT) scans and periapical, lateral cephalometric and/or occlusal radiographs were used for some patient evaluations.

Mounted study casts were used to evaluate proposed implant positions, crown-root ratios, available occlusal dimensions, and jaw relationships. Diagnostic wax-ups and surgical templates to guide implant placement...
were also fabricated. Each case was thoroughly discussed with the patient, and treatment options were presented. All patients signed an informed consent form before treatment.

Clinical procedures
All surgeries were performed in the Oral Implant Center by faculty-student teams using an aseptic technique. The patients were prepared for surgery and anesthetized via nerve blocks and/or local infiltration (2% lidocaine, 1:100 000 epinephrine). Prophylactic antibiotics (amoxicillin/clavulanic acid 500 mg; clindamycin 600 mg; or ampicillin 2 g) were administered 1 hour before surgery and for 3 days postoperative. Primary and secondary releasing incisions were made with a scalpel (#15 Bard-Parker, Becton, Dickinson, and Co, Franklin Lakes, NJ), and full-thickness, mucoperiosteal flaps were carefully elevated to expose the surgical sites. Implant osteotomies were sequentially prepared using internally irrigated drills in graduated diameters according to the implant system’s protocol. Screw-design implants from 2 manufacturers were placed in this study (Table 2). Primary closure of the mucosa was achieved with 3-0 sutures (Vicryl, Ethicon, Inc, Somerville, NJ).

Following surgery, a panoramic radiograph was taken. Postoperative instructions included the use of ice packs for 24 hours to help prevent swelling and analgesics to control pain and discomfort. Sutures were removed approximately 10 days later. All implants were allowed a traditional,11 submerged healing period of 3 (mandible) to 6 (maxilla) months.

At the posthealing recall appointment, patients were anesthetized via local infiltration, primary and secondary releasing incisions were made, and full-thickness, mucoperiosteal flaps were elevated to expose the implants. Clinical osseointegration was evaluated radiographically and by administering manual percussion and lateral pressure on the implants. Transmucosal healing collars were attached to the implants, and the soft tissues were sutured (3-0 Vicryl, Ethicon, Inc) around them according to conventional implant procedures.11 Sutures were removed after 1 week.

Following soft tissue maturation, approximately 2 weeks after implant uncovering, restorative procedures were commenced by faculty-student teams. The implants were restored with single tooth restorations and fixed or removable prostheses in patients with complete or partial edentulism. Radiographs were taken of the restored implants. Patients were provided with extensive hygiene instructions and dismissed until the first prophylaxis appointment 6 months later. After the initial prophylaxis appointment, patients were recalled for monitoring at 12, 24, and 36 months.

RESULTS
A total of 93 implant patients (males = 39, females = 54), ranging in age from 17 to 76 (mean = 48.8; mode = 53) years, were included in the clinical review. Of these, 90 patients were treated exclusively with Branemark (n = 191 implants, 59 patients) or Taper-Lock (n = 91 implants, 31 patients) implants, and 3 patients were treated with a combination of both Branemark (n = 7) and Taper-Lock (n = 14) implants (Tables 3 and 4). The distribution of prosthetic restorations is presented in Table 4.

Implant survival and failure data are presented in Tables 5 and 6. Cumulative implant survival was 94.9% for 198 Branemark implants monitored up to 36 months, 98.1% for 105 Taper-Lock implants monitored up to 36 months.
Plants monitored up to 24 months, and 96% for all 303 implants placed (Table 5). Of the 104 Branemark implants placed in mandibles, 4 failed after 3 months, and 1 failed after 12 months of function (Tables 5 and 6). Among the 94 Branemark implants placed in maxillae, 3 failed after 6 months at the stage-2 uncovering, and 2 failed after 12 months of function (Tables 5 and 6). Four of the 10 Branemark implant failures occurred in 1 patient treated by the same operator. Of 50 Taper-Lock implants placed in mandibles, there were no failures up to 24 months of clinical follow-up (Table 4). Among the 55 Taper-Lock implants placed in maxillae, 1 failed before the stage-2 surgery, and 1 failed after 12 months of function (Tables 5 and 6).

It is important to note that 8 out of 12 implants that failed in this clinical review were placed by 2 operators, only 1 of whom was in the early phases of the learning curve for implant therapy (Table 7).

**DISCUSSION**

The primary study object of determining cumulative implant survival revealed very high outcomes for both implant systems. Taper-Lock implants exhibited a slightly higher (3.2%) survival rate compared to Branemark implants, but the significance of this finding is skewed by differences in the numbers of implants placed (105 vs 198, respectively) and the duration of clinical monitoring (24 months vs 36 months, respectively). In addition, lack of uniform clinical protocols with resultant variations in treatments and techniques may have further influenced the clinical outcome. Although the patients in this study were referred to the Oral Implant Center for treatment of both the surgical and restorative phases of implant dentistry, many returned to their regular dentists for routine maintenance and annual follow-up and, thereby, dropped out of the database.

The design, precision, and strength of the implant-abutment interface are among the primary determinates of component joint integrity and antirotational stability in implant prosthodontics and, thus, have a direct bearing on the long-term functioning of the restoration. Under occlusal
loading, non-axial forces have been reported to destabilize the implant-abutment connection.\textsuperscript{12–13} In general, partially edentulous restorations, especially single-tooth replacements, are subjected to greater lateral bending loads and tipping and elongation forces at the implant-abutment interface and abutment screw than bilaterally splinted implants in edentulous cases.\textsuperscript{12,14–15} This can result in a greater tendency for component joint opening and screw loosening.\textsuperscript{12,16–19} During the relatively short-term (24–36 months) duration of clinical follow-up in the present study, no restorative complications were reported, although it is reasonable to assume that some may arise through long-term functioning.

The phenomenon of marginal bone loss in implant dentistry is a highly complex and sometimes controversial issue. Disruption of the periosteal vascularization through flap elevation, marginal bone flattening, and temperatures generated during the preparation of implant osteotomies can result in early marginal bone loss that is frequently observed during the first year of clinical loading.\textsuperscript{20–21} In addition, the thickness of the residual facial bone plate after preparation of an osteotomy may have a direct bearing on the postoperative marginal bone response in that region.\textsuperscript{22} One prospective, multi-center implant study\textsuperscript{22} found that marginal bone loss significantly decreased, and some evidence of bone gain was observed when the residual facial bone plate measured 1.8 mm to 2 mm in thickness. Conversely, implants that failed to osseointegrate exhibited narrower residual facial bone plates with significantly greater amounts of resorption.\textsuperscript{22}

Once dental implants are placed into function, occlusal overloading and microbial infections have been reported as leading causes of marginal bone loss.\textsuperscript{23–25} Implant overloading can be caused by imbalanced occlusion, an insufficient number of implants to support the restoration, splinting of abutments with non-passive-fitting frameworks, excessively cantilevered pontics, extreme parafunctional forces (e.g., bruxing and clenching), violation of conventional crown-root ratios, and a myriad of other factors. Screw loosening and marginal bone loss are frequently the first detectable signs of occlusal overloading and warrant immediate action.

Balancing occlusion, reducing contacts and surface areas of implant-supported prosthetic teeth, and shortening or eliminating cantilevers whenever possible, are initial steps that can be taken to reduce or eliminate excessive occlusal stress. Elimi-

<table>
<thead>
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<td>Distribution of patients, implants and prosthetic restorations by jaw</td>
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<tr>
<th>Category</th>
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<th>Branemark Mandible</th>
<th>Taper-Lock Maxilla</th>
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<td>22</td>
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<td>50</td>
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<td>Unrestored implants</td>
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<td>Implant survival and failure data by jaw</td>
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<table>
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<th>Taper-Lock Jaw Location</th>
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<tr>
<td></td>
<td>Maxilla No. Placed (No. Failed)</td>
<td>Mandible Cumulative Survival for Interval (%)</td>
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<tr>
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<td>Total</td>
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nating plaque through a comprehensive, home-oral-hygiene regimen and adherence to regularly scheduled prophylaxis appointments are the most effective means of preventing microbial infections. If left untreated, severe marginal bone loss can ultimately lead to implant failure, regardless of its etiology. Due to a lack of standardized measurements in the present study, small marginal bone changes were not included as part of this evaluation.

A prospective clinical study involving 2641 implants placed in 30 study centers defined a learning curve for dental implant placement. Implants placed by surgeons who had previously placed fewer than 50 implants failed twice as often as those placed by surgeons who had previously placed 50 or more implants. Less-experienced surgeons had more implant failures in their first 9 cases than more experienced surgeons. In the present study, lack of surgical experience did not result in a higher failure rate. This may be attributed to the coupling of inexperienced students with experienced faculty members and the smaller number of participating clinicians.

The goal of university-based implant education is to provide emerging dentists with the fundamental skills required for developing expertise in implant dentistry. Over time, this will translate into improved clinical results and a better standard of care for the patient.

**CONCLUSIONS**

Implant survival for both systems was similar at 24 months of follow-up, and clinician experience did not appear to be an influencing variable on implant survival.

**ACKNOWLEDGMENTS**

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**REFERENCES**


