ADA CE Program ARTICLE 1

COVER STORY

Designing a safety checklist for dental implant placement

A Delphi study

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Most surgical procedures involve inherent risks of errors and complications.[1] Despite the best efforts of dental and medical practitioners to provide optimal patient care, errors occur occasionally that result in morbidity and mortality.[1] Error rates vary greatly and depend on the procedure performed, the experience level of the provider, adherence to effective clinical practice protocols, the appropriateness of emergency response protocols and communication between providers.[2,3] These risks are particularly significant in dental procedures that involve complex medical surgery, dental surgery or both.

Replacing missing teeth with dental implants is becoming a treatment of choice,[4] and an estimated 300,000 to 428,000 implants are placed annually in the United States, with a projected growth rate of 12 percent every year.[5,6] Experience in placing implants varies widely

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ABSTRACT

Background. Complications during and after dental implant placement can be a hindrance to successful treatment. Checklists are emerging as useful tools in error reduction in various fields. The authors selected a Delphi panel to explore the appropriate clinical practices involved in implant placement, with the objective of formulating a safety checklist that would aid in reducing errors.
Methods. The authors administered a Delphi method survey to an expert panel of 24 board-certified periodontists to determine if consensus existed regarding the critical steps involved in implant placement. They defined consensus as 90 percent agreement among participants. Using the Delphi data, the authors designed a safety checklist for implant placement.
Results. The panelists generated 20 consensus statements regarding essential steps in implant placement. The authors divided the statements into preoperative, intraoperative and postoperative phases. To determine the rationale for consensus decisions, the authors conducted a thematic qualitative analysis of responses to all open-ended questionnaire items, asking panel members how or why a particular procedure was performed.
Conclusion. The panelists reached a consensus regarding the steps they considered critical in implant placement. Further research is needed to assess the acceptance and effectiveness of this type of checklist in a clinical setting.
Practical Implications. The authors developed a checklist that may be useful in reducing errors in placement of dental implants. If effective, this checklist ultimately will aid in minimizing risk and increasing implant success rates, especially for inexperienced practitioners, dental students, surgical residents and dental implant trainees (that is, dentists undergoing training to place implants through continuing education courses).
Key Words. Dental implants; surgical errors; safety checklists; Delphi technique.
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among clinicians,[7-9] which raises several safety concerns, such as the risk of bleeding complications, altered nerve sensation and aspiration of foreign objects.[10-12] Unfortunately, current frequencies of such dental safety issues and related levels of training in implant surgery are reported only rarely owing to inherent difficulties in standardizing their documentation.[2]

Implant survival rates, on the other hand, are well documented. Many common and easily avoidable errors affect implant survival and success. In one well-controlled study, investigators reported a 95 percent survival rate among dental implants placed by experienced surgeons.[13] However, 39 percent of these implants were associated with at least one complication within five years of placement.[13] Kourtis and colleagues[14] reported a 3.8 percent surgical complication rate, of which 12.31 percent was due to infection. Prosthetic complications, often due to poor mechanical design, occurred in an additional 9.52 percent of these implants.[14] These complications may become amplified when the clinician's experience is limited. For example, implants placed by inexperienced surgeons (< 50 implants) were twice as likely to fail as those placed by experienced surgeons.[15]

Although these error rates may be considered minimal, they are associated with a significant economic and human burden. Errors are an impediment to successful treatment outcomes, adding time and cost to patient care, as well as legal costs that can run into millions of dollars.[16] For patients, errors add considerable discomfort, anguish and loss of time when repeated dental visits are required. Clinicians, meanwhile, face significant financial loss in correcting errors, and, in cases involving more serious errors, they face potential loss of licensure and other possible legal ramifications.[17] In 2012, 11 percent of medical malpractice payments reported to the National Practitioner Data Bank were against dentists.[18] These include medical malpractice payments to patients, which were awarded through lawsuits; settlement payments made by insurance companies on behalf of practitioners; and payments made by the state.[18] Most lawsuits resulted from disappointment with treatment and bodily injury (for example, loss of sensation, oroantral fistula, life-threatening hemorrhage).[19] Considering that complications from incorrectly placed implants may lead to patient dissatisfaction and bodily harm, the need exists for clinical practice guidelines to address potential safety concerns and to reduce errors.

A large percentage of surgical errors are avoidable.[20,21] On the basis of this premise, risk management procedures were developed by Gawande,[3] Gawande and colleagues[21] and Semel and colleagues[22] in the form of a World Health Organization (WHO) surgical checklist intended to reduce human errors in the operating department. This list, modeled after the airline industry's in-flight safety checklists, was implemented with considerable success.[3,21,22] Haynes and colleagues[1] explored the list's utility via a large, multicenter study and reported a 47 percent decline (from 1.5 to 0.8 percent) in patient mortality in cases involving noncardiac surgery and a significant decline (from 11 to 7 percent) in inpatient postsurgical complications. Similarly, Gawande[3] reported that use of a medical checklist over a one-year period resulted in a decrease—from 11 to 0 percent—in the infection rate from central lines 10 days after insertion among patients in intensive care, resulting in an estimated cost savings of $2 million.

We found a paucity of published literature involving dental application of a standardized surgical safety checklist. Pinsky and colleagues[23] proposed a modification of the WHO checklist for use in a dental office setting. Their checklist includes placement of routine dental procedures in a sequence (for example, medical history review, premedication status, anesthetic method) that facilitates identification of potential errors at the earliest point to mitigate any negative consequences.[23] This type of checklist may be beneficial in helping to reduce implant failure rates over time, as well as complications that arise intraoperatively and postoperatively. A checklist similar to the one developed by Pinsky and colleagues[23] also might serve as a teaching tool during surgical training.

The primary purpose of this study was to determine the expert consensus regarding appropriate clinical practices in the restoration of edentulous areas with dental implants and, in turn, to design a preliminary safety checklist for dental implant placement in a clinical setting.

METHODS

Delphi technique. Workshops, consensus conferences and expert panels are qualitative methods used frequently to create consensus about complex clinical problems.[24] The Delphi technique is a structured and effective method for developing expert consensus. This method helps in systematically soliciting and aggregating judgments, as well as in reaching consensus via a sequence of questionnaires.[25-27] The process involves multiple rounds of questions requiring substantial reasoning and reflection by a group of 15 to 30 experts who form considered opinions. The process is carried out anonymously and is repeated, generally two or three times, until a consensus protocol is reached or until any differences of opinion and the reasons behind them are clearly understood.

The Delphi method is advantageous because it allows participants to respond in relatively real time and allows investigators to identify and quantify shifts in perspectives. The goal is to determine whether a consensus exists among the expert panelists, not to force a consensus. Use of the Delphi technique in dental research has

ABBREVIATION KEY. **ABP:** American Board of Periodontology. **NA:** Not applicable. **WHO:** World Health Organization.

TABLE 1

Demographic and practice information for Delphi survey panelists.*

VARIABLE	NUMBER
Expert Panelists Recruited	22 men, 2 women
Implants Placed by all Members of the Panel	101,700
Mean (Standard Deviation) Implants Placed	4,237.5 (3,680.2)
Most Implants Placed	15,000
Fewest Implants Placed	1,200
States in Which Panelists Practiced	14
States in Which Panelists Trained	17
Panelists in Private Practice	12
University Faculty Members	12
Expert Panelists at Completion of Study	20

* These data are based on responses from the initial 24 respondents in the study.

BOX 1

Round 1 summary of responses to open-ended statement.*

SUMMARY OF RESPONSES FROM PANELISTS
▬ Discuss wants, needs and values with patient
▬ There is a need for preoperative treatment planning that includes relevant medical data and preoperative imaging
▬ Conduct a risk assessment, which includes health concerns, oral hygiene adherence, mental attitude toward oral health and care, patient's level of expectations, bone availability, occlusal scheme and patient's esthetic needs
▬ Eliminate and control dental disease, as needed
▬ Discuss costs with patients and ability to pay for treatment
▬ Assess restorative partner's ability to manage the complexity of the case and provide appropriate advice; also discuss with restorative partner and other dental consultants (for example, orthodontists) regarding such issues as stent fabrication
▬ Prescribe appropriate medications for postoperative pain, mouthrinses and antibiotics, when indicated
▬ Conduct a site assessment and site development (for example, ridge augmentation, sinus lift), as necessary
▬ Obtain patient's consent for anesthesia, flap, osteotomy sequence and implant placement, with appropriate intraoperative imaging
▬ Place cover screw or healing abutment and perform flap closure
▬ Obtain radiographs to verify correct implant placement and abutment seating
▬ Check occlusion, obtain periapical radiographs, measure probing depths and provide immediate postprosthetics (such as provisional restorations), if indicated
▬ Schedule postoperative appointments at intervals determined on the basis of clinical judgment
▬ Perform implant maintenance at intervals determined on the basis of clinical judgment
▬ Schedule a one-year follow-up appointment

* Responses represent a compilation of sequential action steps for implant placement proposed by the Delphi panel in response to this open-ended statement: "Briefly describe the clinical maneuvers in each of the steps involved in placing an implant."

been well documented.[27-29] Investigators have used it to develop valid criteria for replacement of amalgam restorations,[27] to create guidelines for construction of complete dentures[28] and to determine criteria for periodontal therapy.[29]

Delphi panel selection. After obtaining ethical approval from the institutional review board at Indiana University, Indianapolis, we selected the Delphi panelists on the basis of predetermined criteria. We used a purposeful, nonrandom sampling technique to select panelists. We set the panel size at a high number of 30 participants on the basis of previous Delphi studies in dentistry in which investigators included between 15 and 30 panelists.[30,31] We identified potential panelists through the American Board of Periodontology's (ABP) online database and contacted them via e-mail to determine interest. The criteria used to determine clinical expertise to participate in the Delphi panel included being an active Diplomate of the ABP, being active in placing dental implants for at least five years, having placed at least 1,000 implants and reporting that placement of dental implants constitutes a significant portion of the clinician's practice.

Delphi survey instruments. Three of us (A.C., S.S., S.P.) used a web-based tool (SurveyMonkey, Palo Alto, Calif.) to administer the Delphi panel survey in a manner allowing respondents to reply anonymously. The investigators served as moderators and categorized responses to questions during each round. We distributed the analyzed, modified and reconstructed statements as they evolved in each round.

Round 1. We collected demographic data from all survey participants: sex, nature of practice (part time versus full time), university affiliations, practice location (state) and institution (state) at which dental implant training was received. We also requested the following practice details: the total number of implants placed in clinical practice, number of years in practice, and number of years placing implants. In addition, during round 1, we asked panelists to respond to a key open-ended statement: "Briefly describe the clinical maneuvers in each of the steps involved in placing an implant." We compiled the responses into a description of sequential action steps and sent it to panelists with requests for comments or suggestions for alternative wordings for any statements

TABLE 2

Treatment planning steps proposed by expert panel (N = 20).

QUESTIONNAIRE ITEM	INITIAL CONSENSUS	SUMMARY OF QUALITATIVE RESPONSES	REWORDED QUESTION OWING TO LESS THAN 90% CONSENSUS	NEW CONSENSUS	REASONS FOR DISAGREEMENT, IF ANY
Verify Periodontal Stability	100%	Probing depths, attachment levels, recession, mobility, fremitus, occlusal interferences, alveolar bone levels, alveolar bone loss, furcations, bleeding, amount of keratinized tissue, tooth migration and supereruption, suppuration	NA*	NA	NA
Use Diagnostic Aids	100%	Periapical, bitewing and panoramic radiographs; computed tomographic scans; photographs and study models	NA	NA	NA
Identify Anatomical Structures	100%	Identify sinuses, nerves, foramen and other anatomical structures by using radiographic and clinical diagnostic aids	NA	NA	NA
Review Medical and Dental History	100%	Written or oral interview conducted to make efficient diagnoses and treatment plans, to identify medical contraindications to surgery, to identify medical and dental conditions that may affect treatment and healing, to become aware of medical or dental conditions that may lead to complications	NA	NA	NA
Develop Formal Treatment Plan With Restorative Partner	60%	Team approach works best; surgeon often is principal driver in routine implant cases; a formal treatment plan often is needed for complex cases only	Is a formal treatment plan with your restorative partner important as part of good clinical practice?	90%	10% of panelists reported that they did not believe a formal treatment plan was necessary in simple cases (that is, placement of one or two implants at a time)
Obtain Signed Treatment Plan and Consent Form	90% of patients signed a consent form; 75% signed a treatment plan; 95% received a copy of treatment plan (signed or unsigned)	Signed consent important for legal protection; treatment plans given to patients to ensure they understand proposed treatment and to make sure patient and clinician are in agreement on all aspects of surgical plan	NA	NA	NA
Check Stockroom Daily	No clear consensus	Only one panelist reported that stockroom was checked daily; all others reported that this was done as needed by staff members	NA	NA	NA

* NA: Not applicable.

or for any new clinical items. In addition, we asked panelists to indicate disagreement with any of the sequential action steps provided by the researchers (A.C., S.S., S.P.).

Round 2. We generated the round 2 questionnaire items by providing participants with an integrated list of the sequential steps for placing dental implants. This list was developed on the basis of participants' responses from round 1, published evidence-based research findings pertaining to implantology[32-37] and our own clinical experience in placing implants. This questionnaire was divided into three sections: treatment planning, intraoperative and postoperative. Each section contained a series of questions requiring yes or no responses. These items were followed by appropriate open-ended questions (for example, "How?" "Why?" "Which ones?"). The questionnaire also asked panelists to explain their reasoning for including each sequential step.

We analyzed the responses and calculated the percentages of yes and no answers. One of us (A.C.) entered all responses to open-ended questions into a database. We removed statements that indicated no chance of consensus, and we reworded some of the sequential action

TABLE 3

Intraoperative steps proposed by expert panel (N = 20).

QUESTIONNAIRE ITEM	INITIAL CONSENSUS	SUMMARY OF QUALITATIVE RESPONSES	REWORDED QUESTION OWING TO LESS THAN 90% CONSENSUS	NEW CONSENSUS	REASONS FOR DISAGREEMENT, IF ANY
Review Medications, Medical History, Dental History on Day of Surgery	100%	Done by oral review the day of surgery to ensure there are no changes in the medical or dental status	NA*	NA	NA
Examine and Protect Vital Structures and Airway During Surgery	85% answered yes, but there were multiple interpretations of this question	Varied interpretation of question by panelists; hence, no clear qualitative assessment of agreement could be made	Should surgeons protect the airway during surgery to prevent aspiration of objects? Should surgeons monitor vital signs if conscious sedation is used?	Airway, 90%; vital signs, 100%	Airway should be protected whenever possible; 55% of panelists mentioned use of a gauze throat pack; methods of monitoring vital signs included visual monitoring and use of pulse oximeter
Adhere to Manufacturers' Recommended Drill Speeds and Torque Values	80%	Drill speeds and torque values should be based on clinical experience and bone quality rather than on manufacturers' recommendations	Should surgeons follow manufacturer-recommended drill speeds and torque values during implant placement?	80%	Drill speeds and torque values should be adjusted on the basis of clinical experience and patient's bone quality
Obtain Intraoperative Radiographs	90%	Do so if there is a concern about proximity to vital structures	NA	NA	NA
Ask a Qualified Assistant to Verify Drill Positioning	70%	Obtaining a second viewpoint to ensure proper angulation/placement is helpful; however, some panelists suggested that the surgeon ultimately is responsible for placement	Should surgeons enlist the aid of a trusted assistant to verify drill position during implant placement? Is this part of good clinical practice?	90%	Panelists stressed that accurate drill positioning ultimately is the surgeon's responsibility
Use a Surgical Guide	50%	Suggested by respondents for use in maxillary anterior sites and in fully edentulous patients, along with cases involving multiple implants; respondents expressed doubt as to usefulness of guides fabricated by restorative partners or laboratories	Should surgeons use a surgical guide in anterior cases? in cases involving multiple implants? in cases involving edentulous patients?	No consensus: only 10 panelists (50 percent) agreed that it is an essential step	Although all respondents confirmed the usefulness of surgical guides in some cases, there was no consensus on when or in what way guides were critical
Obtain Final Radiographs	90%	Confirm cover screw or abutment seating; radiographs needed before restorative phase to confirm osseointegration	NA	NA	NA

* NA: Not applicable.

steps to take into account additional commentary from participants regarding how or why they suggested a step. At this point, any steps for which there was less than 90 percent agreement were sent back to the panelists for review, and we asked them this question: "Do you think the proposed action is important as part of good clinical practice for implant placement?"

In addition, we conducted a thematic analysis[38] of data in round 2 for all of the open-ended questionnaire items. (A thematic analysis involves examination of themes in the data and focuses on identifying explicit and implicit ideas.[38]) We conducted this descriptive analysis to determine the rationale for certain consensus decisions and to postulate an explanation of why the panelists recommended that particular procedures be performed.

Round 3. Using round 2 data, we compiled a draft implant checklist consisting of items for which there was 90 percent or greater agreement, and we distributed it to participants for examination. We summarized areas of consensus reached by panelists on examining the draft implant checklist, and we suggested concluding action steps (such as indicating any needed modifications) to create a refined preliminary checklist of critical or essential steps involved in implant placement. We elicited agreement or disagreement with this refined preliminary checklist so that we could design a final version of the preliminary safety checklist for implant placement.

Data analysis. The use of three successive rounds

TABLE 4

Postoperative steps proposed by expert panel (N = 20).

QUESTIONNAIRE ITEM	INITIAL CONSENSUS	SUMMARY OF QUALITATIVE RESPONSES	REASONS FOR DISAGREEMENT, IF ANY
Prescribe Postoperative Antibiotics	80% routinely prescribed postoperative antibiotics for all implant placements; 95% prescribed postoperative antibiotics if bone graft was placed with implant	80% specifically mentioned use of penicillin-class antibiotics as first choice, followed by clindamycin if allergies were a concern; antibiotics prescribed to prevent postoperative infection and improve chances for successful placement and integration	20% noted absence of evidence for routine use of postoperative antibiotics with routine implant placement (without grafting); therefore, universal use of antibiotics did not receive full agreement
Prescribe Postoperative Mouthrinse	90%	All respondents who recommended postoperative mouthrinses suggested chlorhexidine, 0.12% or 0.2%, for plaque control	NA*
Provide Written Postoperative Instructions	100%	Ensure that patient understands what to expect; teach patients to care for surgical site; instruct patients in use of postoperative analgesics; important for medicolegal reasons	NA
Provide Postoperative Notes to Restorative Partner	80% provided notes immediately after placement; 20% did so after implants were integrated and ready for restorative procedure	100% agreed that postoperative communication between the surgeon and restorative dentist is important; step conducted to make sure all providers are informed during treatment, information regarding implant size and manufacturer is communicated, and needed prosthetic components are procured	A panelist noted that a communication delay may exist until the implant is ready to be restored to ensure that the final restoration is not placed too soon
Schedule Postoperative Telephone Calls and Appointments	95% reported telephoning patients within 1 to 2 days of surgery; 100% scheduled regular postoperative follow-up appointments	Telephone calls made to ensure that patients are managing pain adequately and to answer any questions about healing; follow-up appointment times varied (visits reported at 1 week, 10 days, 2 weeks, 4 weeks, 6 weeks and 3 months)	One panelist noted that patients were advised to call with any concerns after surgery

* NA: Not applicable.

positively affects the content validity of our Delphi study.[38] As suggested by Fink and colleagues,[39] we defined an expected consensus level in advance for this study. Hasson and colleagues[40] and Sumsion[41] suggested that investigators conducting Delphi studies use a 70 percent consensus level as a benchmark to maintain rigor of the technique. Because the aim of our study was to determine key steps involved in dental implant placement, we set a considerably higher minimum level of consensus—90 percent—for inclusion of a step in the final safety checklist. This high minimum level of consensus enhances the validity of the study. We omitted from the final checklist any items for which there was less than 90 percent agreement; however, we analyzed in full the descriptive data relevant to those items.

RESULTS

Panel composition. We identified 100 Diplomates from ABP according to our selection criteria. A total of 24 people (22 men and two women) agreed to serve on the expert panel. Twenty people completed all three rounds. Self-reported data regarding the panelists' demographics and dental practices at the start of the study are as follows: mean (standard deviation [SD]) time in practice, 22.3 (8.0) years and mean (SD) number of implants placed in their careers, 4,237.5 (3,680.2). Participants practiced in 14 states and received surgical training in implant placement in 17 states. Twelve panelists worked full time in private practice, and 12 were university faculty members (Table 1).

Round 1. We summarized panelists' responses to the initial open-ended statement (Box 1) and returned them for agreement and further commentary. All panelists (N = 24) agreed with the summary without additional comment. Their responses included various steps involved in implant dentistry, including treatment planning, implant placement and follow-up. Panelists' responses covered a wide range of topics (for example, patients' desires, risk assessment, treatment planning, site development, communication with restorative partners, follow-up procedures and maintenance appointments).

Round 2. We integrated the responses from round 1 to generate the round 2 questionnaire (shown in the appendix in the supplemental data to the online version of this article [found at http://jada.ada.org/content/145/2/131/suppl/DC1]), as described earlier. Most steps in this round achieved 90 percent or greater agreement (Tables 2 through 4) among the panelists (N = 20). Steps

that did not achieve consensus included the following: formal treatment plan with restorative partner; signed treatment plan; daily stockroom check; examination and protection of vital structures, airway or both during surgery; adherence to manufacturers' recommended drill speeds and torque values; use of surgical guides; help of a qualified assistant to verify drill positioning; and prescription of postoperative antibiotics.

When we reworded these steps to ascertain if there was a reasonable chance of achieving consensus (Tables 2 through 4), 90 percent or greater agreement was achieved for these items: formal treatment plan with restorative partner; giving patients a copy of the treatment plan; protecting airways, vital structures or both; and routine use of antibiotics when bone grafts are placed with implants. Adherence to recommended drill speeds and torque values and use of a surgical guide did not achieve the 90 percent agreement threshold. We made no attempt to achieve consensus for the daily stockroom check owing to the wide variety of negative responses. We completed the thematic qualitative analyses of the responses to round 2 items and summarized the panelists' reasoning and rationale for disagreeing with certain steps (Tables 2 through 4). Our analyses also focused on the details of each step, such as panelists' reporting that verification of periodontal stability must be achieved by means of clinical and radiographic evaluations of probing depths, attachment levels and alveolar bone levels.

Round 3. We then designed a preliminary safety checklist that included the 20 items for which there was at least 90 percent agreement in round 2 (Box 2). We did not include three statements for which agreement was less than 90 percent. We then returned the checklist to the panelists for evaluation and determination of final agreement for each item. All respondents approved the checklist, with some reemphasizing previously stated disagreements regarding certain details. A few panelists mentioned some additional steps in this round, for which consensus of at least 90 percent was not achieved. These statements are as follows:

- There is a need to monitor vital signs of certain patients who do not receive sedation, especially those who have a significant medical history.
- If applicable, the clinician should ensure that the patient has provisional dentures if an immediate-load, full-arch prosthesis is planned.
- Check for irrigation of the osteotomy site.

BOX 2

Preliminary checklist for implant placement.

TREATMENT PLANNING PHASE
▬ Verify periodontal stability by means of clinical and radiographic assessment
▬ Review diagnostic aids (such as radiographs, computed tomographic scans, models)
▬ Identify key anatomical structures (such as inferior alveolar nerve, mental nerve, sinus floor, lingual concavity)
▬ Review medical and dental history, including current medications
▬ Review treatment plan with restorative dentist
▬ Verify that signed patient consent form has been obtained
▬ Verify that patient has copy of treatment plan
INTRAOPERATIVE PHASE
▬ Review medical and dental history before procedure
▬ Monitor vital signs if sedation is administered
▬ Protect the airway when appropriate
▬ Obtain and review intraoperative radiographs if there is limited space or nearby anatomical structures are of concern
▬ Ask a competent dental assistant to verify drill position
▬ Obtain final radiograph to verify implant position and seating of abutment or cover screw
POSTOPERATIVE PHASE
▬ Prescribe antibiotics if bone graft is placed along with implant
▬ Prescribe chlorhexidine or other postsurgical mouthrinses
▬ Obtain radiograph to confirm osseointegration before restorative procedure
▬ Schedule follow-up appointment or appointments with patient
▬ Provide written postoperative instructions to patient
▬ Telephone patient after surgery to gauge recovery from procedure
▬ Provide postoperative notes to restorative partner after osseointegration

DISCUSSION

In this study, we set out to determine the expert consensus among periodontists regarding the appropriate clinical action steps for the successful restoration of edentulous areas with dental implants. The Delphi panel ultimately determined that 20 checklist items were essential (≥ 90 percent agreement) in the treatment planning, intraoperative and postoperative phases of implant placement. The general consensus among the group was as follows:

- In preparing treatment plans for patients, clinicians should verify periodontal stability, conduct a proper diagnostic work-up and engage in effective communication with restorative partners.
- It is important to review the patient's medical and dental history before placing implants and to build safety checks into the implant placement procedure.
- Postoperative care includes appropriate communication with restorative partners and patients.
- Implant maintenance is an integral part of follow-up care for patients who have received dental implants.

In this study, we explored the steps involved in implant surgery to standardize implant placement protocols by designing a clinically practical safety checklist, with the explicit aim of reducing human errors.

With complex clinical decision-making systems, health care practitioners face two main challenges[3,21]: the fallibility of human memory and attention (especially

under the strain of more pressing events, such as intraoperative surgical complications) and practitioners' tendency toward being lulled into skipping memorized and routinized clinical steps in a surgical procedure. Despite having received extensive education and training in surgical principles and in the correct sequential procedures, some clinicians tend to assume that certain critical steps may not always be necessary.[3] Therefore, another reason to design a safety checklist is to make the routinization of procedures explicit. This list could provide clinicians with clear reminders of the minimum steps necessary in implant placement, with the aim of avoiding or catching any significant procedural errors.[3]

Treatment planning steps. The first section of the survey explored critical steps in the treatment planning phase. As shown in Box 2, seven steps achieved 90 percent consensus. The panelists stated that verification of patients' periodontal stability was critical, and they emphasized the need for thorough clinical and radiographic evaluation to establish this stability. This finding is consistent with the literature in which investigators described compromised success of dental implants in patients with uncontrolled periodontitis.[34,35] Panel members also pointed to the use of appropriate diagnostic aids—such as radiographs and cone-beam computed tomography—and the identification of key anatomical structures as critical steps. The consequences of failure to identify and protect key anatomical structures are documented extensively in the literature. In a meta-analysis of complications related to implant placement, Goodacre and colleagues[10] found that the most common surgical problems encountered—about 24 percent—were related to hemorrhage. The incidence of persistent or long-term altered sensation of the mental nerve after implant surgery has been reported to vary from 1 to 43 percent.[42-44]

The Delphi panelists also agreed that a review of the patient's medical and dental history is critical for preventing medical emergencies, as well as for identifying relative or absolute contraindications to implant placement. Nineteen of the 20 panelists (95 percent) agreed that it is critical to have a formal treatment plan in place for complex cases, and 18 respondents (90 percent) agreed that obtaining a signed consent form from patients for proposed treatment is important from a legal standpoint to reduce the risk of possible malpractice suits. Finally, panel members agreed that patients should receive a copy of the treatment plan.

Intraoperative steps. Six steps attained 90 percent agreement (Box 2). All 20 panelists concurred that a review of current medications and an exploration of any changes to the patient's dental or medical history must be done on the day of surgery. Ninety percent of the panelists agreed that protection of the airway is critical, with the caveat that doing so often is difficult owing to space restrictions. The dental literature contains reports of sporadic occurrences of surgical instrument aspiration and associated life-threatening complications.[12,45,46] Worthington[46] reported a case of a patient who swallowed a mini screwdriver, resulting in serious consequences, including infection and blockage.There also have been occasional media reports of deaths related to aspiration of small objects during dental implant placement.[17] Panelists in our study advocated the use of safety maneuvers, such as placing gauze at the back of the throat and monitoring vital signs during administration of conscious sedation; these results are consistent with those in the literature.[2]

Only 16 respondents (80 percent) agreed that it was important to adhere to manufacturers' recommendations regarding drill speeds and torque values. Consistent with research findings reported by Greenstein and colleagues,[36] several panel members suggested that sound clinical judgment and evaluation of bone quality are the most important factors in determining drill speeds and torque values. Reported primary causes of initial integration failures of implants include excessive heat due to drilling (that is, higher speed during preparation of the osteotomy) and excessive pressure at the implant-bone interface (greater torque values) at the time of implant insertion,[47] which may result in retrograde peri-implantitis lesions.[48]

Eighteen respondents (90 percent) agreed that intraoperative radiographs are essential in areas with limited space owing to anatomical constraints. Ninety percent also agreed that verifying implant angulation and positioning with the help of a qualified assistant and obtaining final radiographs after implant placement are critical steps. Tarnow and colleagues[49] reported that improper mesiodistal angulation and positioning of implants can lead to lateral bone loss, as well as unacceptable esthetic results. Invasion of the periodontal ligament space, devitalization of adjacent teeth due to improper angulation and positioning, or both are other concerns related to improper placement of implants,[50] and these complications often can go unreported.

Postoperative steps. Finally, we explored the postoperative steps needed for the success of dental implants. Consistent with findings in the literature, the panelists in our study stated that prescribing chlorhexidine mouthrinses (90 percent agreement), providing patients with written postoperative instructions (100 percent), communicating after surgery with restorative partners (100 percent), making follow-up telephone calls to patients (95 percent) and setting up follow-up appointments (100 percent) were essential clinical practices.[2,16,36,37] Reported postoperative infection rates are low (0.7-1.14 percent),[51,52] but those that occur can lead to serious adverse events beyond the oral cavity.[2,16] Therefore, following a prescribed, standardized safety checklist may prove useful in reducing errors associated with implant placement.

Study limitations. One of the study's limitations is that the anonymity of responses made it difficult to determine which participants completed the process. Also,

because we conducted the Delphi panel survey electronically, there may have been some loss of key concepts that might have been expressed in a face-to-face interaction. Conversely, this process may be viewed as a positive aspect of the study, in that requesting participants to answer questions individually may have precluded group pressure to achieve consensus quickly.

CONCLUSIONS

We have described the decision-making process involved in designing a preliminary safety checklist for implant placement. To our knowledge, this may be the first attempt to design a standardized safety checklist for dental implant surgeries. The safety checklist can be used in paper form or integrated with an electronic medical record or, alternatively, it can be used as a mobile application. The panelists in this Delphi study, who were from academic and private practice settings, had a wide range of expertise and significant practice experience.

Further research is needed so that this preliminary checklist can be clinically field tested, as was the case with the WHO checklist. Investigators need to determine if the use of such a checklist in a controlled study can lead to the reduction of error rates. Researchers also need to explore the perceived clinical usefulness of such a checklist among practitioners and the reasoning behind their acceptance of, or resistance to, the checklist in the practice of dental implant placement. A body of evidence supports the use of checklists in reducing errors in a surgical setting.[1,3,20–23] The preliminary safety checklist we have proposed may aid similarly in reducing errors during implant placement. ■

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