A Literature Review On The Performance Of Narrow-Diameter Implants For Long-Term Overdenture Applications In Maxillary And Mandibular Jaws

Renée M. Stach[†], DDS

[†]Dr. Renée Stach is an employee of BIOMET ***3i*** LLC.

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Background

The application and popularity of small-diameter implants or "mini-implants" has advanced significantly since they were first introduced to the market in the 1990s. The first "mini-implants" were approximately 1.8mm to 2.0mm in diameter, machined-surfaced and designed so that they could be placed with minimal disruption to the alveolar bone. Their initial intended use were as transitional devices for temporary stabilization of a patient's immediate prosthesis during the healing phase of submerged standard-diameter implants (SDIs) planned for support of permanent restorations. When used as a transitional device, the mini-implant could provide adequate stability and enhanced mastication while allowing the buried SDIs to osseointegrate during the conventional 4-6 month healing protocol. While mini-implants were generally removed at the end of the transitional period, they were discovered to have osseointegrated to the same extent (bone-to-implant contact) as SDIs [Froum et al. 2005; Zubery et al. 1991].

Due to these findings, the designs and applications of mini-implants have evolved and today they are more commonly referred to as narrow-diameter implants (NDIs), having diameters ranging from 2.2mm to 3.0mm and with surface enhancements to further promote their use as permanent implants. NDIs are appropriate for severely resorbed edentulous regions or narrow ridges, are placed without surgical flap reflection and can be used to support both removable appliances and fixed restorations. When financial considerations play a role in treatment decisions, NDIs are also good options for the edentulous patient.

Objective

The aim of this report is to determine survival rates of narrow-diameter implants placed for long-term stabilization of overdentures in either jaw.

Methods

Literature Search and Strategy

A literature search for journal articles published on clinical studies with outcomes for narrow-diameter implants (NDIs) placed in support of mandibular and/or maxillary overdentures was conducted. Additional inclusion criteria for final selection of studies included the following: NDI diameter ≤ 3.0mm, prospective or retrospective study designs and a follow-up duration ≥ 12 months. Studies needed to provide data on the surgical flap reflection procedure, patient and implant numbers, jaw location, duration of follow-up observations, and cumulative survival rates (CSR). Studies excluded from final selection were those treating patients for transitional overdenture applications or in which data for permanent prostheses could not be separated from overdenture data.

The MEDLINE-indexed database was accessed at the PubMed.gov webpage and literature searches were conducted using the following keywords and combinations: "dental, implant, narrow, small, mini, diameter, mini-implant, overdenture, edentulous". Search filters included activation of: Humans, Journal type = Dental journals and Search field = Title/Abstract. The search strategy initially focused on selection of systematic reviews for NDIs that would yield the best potential sources of clinical data.

Clinical Data Selection Process

Figure 1 illustrates the selection process for the NDI overdenture clinical studies for this report. The four most recent systematic reviews were selected from the initial literature search: Ortega-Oller et al. 2014*, Klein et al. 2014*, Gleiznys et al. 2012* and Sohrabi et al. 2012*. Each of these articles reviews a distinct number of clinical studies (ranging from 16 to 41) on NDIs of varying diameters and used for different applications. All clinical studies reviewed were between 1995 and 2012. From these articles, clinical studies were selected based on data presented that met

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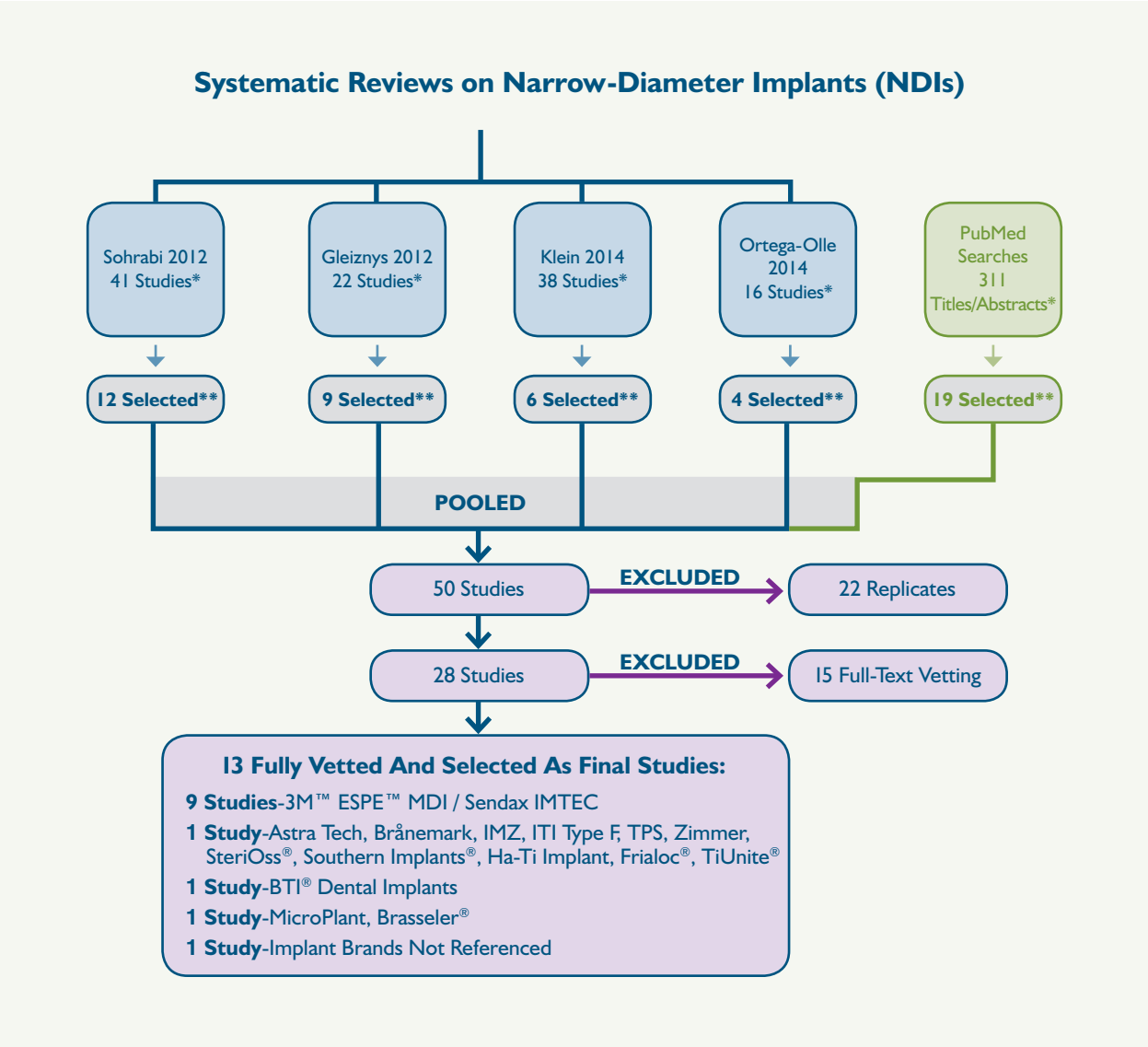

Figure 1. Literature Selection Strategy Process for Narrow-Diameter Implant (NDI) Overdenture Studies.

the inclusion criteria. A literature search was conducted in PubMed retrieving 311 Titles/Abstracts* that were screened for publications not captured in any of the four systematic review articles. From the 311 Title/Abstracts, 19 additional studies were identified, giving a pooled total of 50 studies that fit the inclusion criteria. Within the pooled total, 22 replicates were identified and subtracted to yield a total of 28 studies. At this point in the selection process, the 28 full-text articles were vetted for relevance and inclusion, concluding in a final selection of 13 studies from which clinical data on NDIs supporting overdenture-prostheses could be extracted.

Results

Clinical Data

The 13 studies were published between 2005 and 2014 and include overdentures in both the mandible and maxilla. The following clinical data were extracted from each study and are presented in Table 1 (*see page 3*): study design and center, NDI diameter, surgical flap reflection (yes/no), numbers of patients and implants, location by jaw, duration of follow-up observations in months (or range), and percent cumulative survival rate (CSR%). Implant brands used in the studies are also presented.

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Studies that included BIOMET ***3i* Implants did not meet the inclusion criteria for this literature review and were excluded in the selection process. BIOMET ***3i*** Implants are not part of the clinical data examined in this paper.

Reference 1st Author(s), Year	**Study Design**	**Implant Brands**	**NDI Diameter** (mm)	**Surgical Flap**	**N: Patients N: NDIs**	**Location by Jaw**	**Follow-up Duration** (months)	**CSR** (%)
Bulard & Vance 2005	RETRO Cohort Multi-Center	3M™ ESPE™ MDI / Sendax IMTEC	1.8 2.1 2.4	No	NA Patients 1,029 NDIs	MAX & MAND	[4 to 96]	91.2
Griffitts et al. 2005	PRO-OBSV Single Center	3M™ ESPE™ MDI / Sendax IMTEC	1.8	No	24 Patients 116 NDIs	MAND	18	97.4
Cho et al. 2007	RETRO Case Series Single Center	Astra Tech, Brånemark, IMZ, ITI Type F, TPS, Zimmer, SteriOss®, Southern Implants, Ha-Ti Implant, Frialoc®, TiUnite®	2.5 3.0 3.3	No	10 Patients 34 NDIs	MAND	23	94.1
Anitua et al. 2008*	RETRO Cohort Single Center	BTI® Dental Implants	2.5 3.0 3.3	Yes	NA Patients# 911 NDIs	MAX & MAND	29	99.0
Labarre et al. 2008	RETRO Single Center	3M™ ESPE™ MDI / Sendax IMTEC	1.8 2.1 2.4	Mixed	(~)156 Patients 626 NDIs	MAND	[Up to 72]	92.6
Morneburg & Pröschel 2008	PRO-OBSV Case Series Single Center	MicroPlant, Brasseler®	2.5	N/A	67 Patients 134 NDIs	MAND	72	95.5
Anitua et al. 2010**	RETRO Cohort Multi-Center	3M™ ESPE™ MDI / Sendax IMTEC	2.5 3.0	Yes	51 Patients 89 NDIs	MAX & MAND	48	98.9
Jofré et al. 2010	PRO-RCT Single Center	3M™ ESPE™ MDI / Sendax IMTEC	1.8	No	45 Patients 90 NDIs	MAND	24	100
Elsyad et al. 2011	PRO-OBSV Single Center	3M™ ESPE™ MDI / Sendax IMTEC	1.8	No	28 Patients 112 NDIs	MAND	36	96.4
Shatkin & Petrotto 2012	RETRO Cohort Single Center	Implant Brands Not Disclosed	1.8 2.1 2.4	No	1,260 Patients 2,200 NDIs	MAX & MAND	42 [1 to 144]	88.1
Mundt et al. 2013	RETRO Multi-Center	3M™ ESPE™ MDI / Sendax IMTEC	1.8 2.1 2.4	No	133 Patients 738 NDIs	MAX & MAND	[7 to 61]	95.9
Maryod et al. 2014	PRO-RCT Single Center	3M™ ESPE™ MDI / Sendax IMTEC	1.8	No	30 Patients 120 NDIs	MAND	36	94.2
Preoteasa et al. 2014	PRO-OBSV Single Center	3M™ ESPE™ MDI / Sendax IMTEC	1.8 2.1 2.4	No	23 Patients 110 NDIs	MAX & MAND	36	92.7

KEY

NDI = Narrow Diameter Implant; OVD = Overdenture; NA = Not Available; N = Number; mm = Millimeter; PRO = Prospective; OBSV = Observational; RETRO = Retrospective; RCT = Randomized Controlled Trial; MAX = Maxilla; MAND = Mandible; CSR = Cumulative Survival Rate.

Footnotes

* This study also includes implants with diameters of 3.75mm and above (N = 4,876). The number of implants and the CSR reported in the table are clinical data for the NDIs exclusively.

** This study includes OVDs (30.3% of NDIs), fixed partial dentures (55.1%) and single tooth restorations (13%). Clinical data reported in the table for Patient (N), NDI (N) and CSR (%) are for all study implants and treatment modalities. The patient number is for the total number of patients in the study; the number of patients with OVDs cannot be separated.

This study includes both OVDs and fixed prostheses. The total number of patients in the study is 1,060; the number of patients with OVDs cannot be separated.

(~) Patient number was not specified in this study but the number is based on four NDIs per each MAND OVD per Methods section.

Table 1. Clinical Data on Narrow Diameter Implant Supported Overdentures.

CATEGORIES OF STUDIES	N0.
Studies By Design	
Prospective Observational: 3M™ ESPE™ MDI / Sendax IMTEC MicroPlant, Brasseler®	4
Prospective Randomized-Controlled Trials: 3M™ ESPE™ MDI / Sendax IMTEC	2
Retrospective: Astra Tech, Brånemark, IMZ, ITI Type F, TPS, Zimmer, SteriOss®, Southern Implants, Ha-Ti Implant, Frialoc®, TiUnite®, BTI® Dental Implants, 3M™ ESPE™ MDI / Sendax IMTEC	7
Studies By NDI Diameter	
1.8 mm	4
1.8 - 2.4mm	5
2.5 - 3.0mm	3
2.5 - 3.3mm	1
Studies by Surgical Flap Reflection	
Yes	2
No	9
Mixed	1
Surgical Flap Reflection not mentioned (*excluded*)	1
Studies by Overdenture Jaw Location	
Mandibular Overdentures	7
Maxillary Overdentures	0
Overdentures in Both Jaws	6

Table 2. Total of Studies by Categories.

GROUPS OF STUDIES	DATA
All 13 Studies with Clinical Data: 3M™ ESPE™ MDI / Sendax IMTEC, Astra Tech, Brånemark, IMZ, ITI Type F, TPS, Zimmer, SteriOss®, Southern Implants, Ha-Ti Implant, Frialoc®, TiUnite®, BTI® Dental Implants, MicroPlant, Brasseler®	**92.5%** 6,309 NDIs
Selected 10 Studies (With 3 Excluded)*: 3M™ ESPE™ MDI /Sendax IMTEC, Astra Tech, Brånemark, IMZ, ITI Type F, TPS, Zimmer, SteriOss®, Southern Implants, Ha-Ti Implant, Frialoc®, TiUnite®	**97.5%** 2,454 NDIs
Selected Studies with CSRs for Mandibular Overdentures: 3M™ ESPE™ MDI / Sendax IMTEC, Astra Tech, Brånemark, IMZ, ITI Type F, TPS, Zimmer, SteriOss®, Southern Implants, Ha-Ti Implant, Frialoc®, TiUnite®, MicroPlant, Brasseler®	**96.8%** 680 NDIs

Table 3. Weighted Mean and Totals of Narrow-Diameter Implants.

Summary Statistics

The totals of studies by categories are presented in Table 2. Of the 13 studies, six are prospective and seven are retrospective and most (10) are single-center, with one being a university center at which undergraduate students performed the procedures (LaBarre et al. 2008). Studies listed by diameter show four being 1.8mm NDI and five having diameter sizes of 1.8mm, 2.1mm and 2.4mm, which are components of the MDI system (3M™ ESPE™ Dental Products) designed with an O-ball attachment for overdentures. Studies listed by surgical flap reflection show the majority (10) as minimally invasive (no flap reflection). Seven studies were populated exclusively with edentulous mandibular patients; there are no studies reporting on maxillary cases exclusively. For the 10 studies reporting duration of follow-up observations, the overall mean is three years and the range is 1.2 to six years.

Table 3 shows the weighted mean (WM) CSR for all 13 studies following a total 6,309 NDIs is 92.5%. A WM-CSR has also been calculated for a Selected 10 Studies with the exclusion of three large retrospective studies (Bulard & Vance 2005, LaBarre et al. 2008 and Shatkin & Petrotto 2012) that lack the specificity critical to an evaluation of clinical data. In particular, these studies do not perform Kaplan Meier survival analyses, the number of patients lost-to-follow-up is unreported and two do not include duration of follow-up, which generates a CSR that is unreliable. Despite two publications having been cited in the systematic review articles (Bulard & Vance 2005; Shatkin & Petrotto 2012), all three are published in journals not included on Thomas Reuter's dental journals list for Impact Factors, which also justifies our decision to exclude them from this calculation. With these three studies excluded, the WM-CSR for the Selected 10 Studies and 2,545 NDIs is 97.5% (Table 3) – a comparable performance outcome to standard-diameter implants (Renouard & Nisand 2006).

Also of interest are clinical data for overdentures in the mandible and seven of the Selected Studies report on patients treated for edentulous mandibles, exclusively. Additionally, in Proetassa et al. 2014, the CSR for 74 mandibular overdenture NDIs is 100% with a mean follow-up of 36 months. For these selected seven studies, a total of 227 patients received 680 NDIs (average 3.0 NDI per OVD) and have a WM-CSR of 96.8% with a mean duration of 35 months (Table 3.).

Conclusion

1. NDI systems have transitioned from being used as temporary support devices to long-term stabilization implants.
2. An abundance of long-term clinical data is available to document their utility and performance for overdenture applications in both jaws.
3. Clinical performance rates of NDIs are similar to those of standard-diameter implants.

*The following retrospective studies were excluded due to the lack of specificity on critical data:
Bulard & Vance 2005, LaBarre et al2008, and Shatkin & Petrotto 2012.

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