J Oral Med Oral Surg 2022;28:28
© The authors, 2022
https://doi.org/10.1051/mbcb/2022008

https://www.jomos.org

JOMOS
Journal of Oral Medicine and Oral Surgery

Systematic Review

Analysis of retrieval of dental implants displaced into ectopic locations between 2015–2017 and 2018–2020: scoping review of literature

Tadakazu Miyao[1], Shigeo Osato[1,*], Irika Miyao[1], Yukari Nakajima[1], Masayori Shirakawa[2]

[1] Dento-Oral Science Institute, Chiyoda-ku, Tokyo, 102-0072 Japan
[2] School of Dentistry, Meikai University, Saitama, 350-0283 Japan

(Received: 9 September 2021, accepted: 20 January 2022)

Keywords:
Dental implant displacement / dental implant retrieval / endoscopy

Abstract – Purpose: This study aimed to evaluate differences in 10 items of treatment details in patient regarding cases between 2015–2017 (EP) and 2018–2020 (LP) from scoping literature review of displaced dental implant (DDI) retrievals. **Materials and methods:** PubMed, Google Scholar, and ScienceDirect were searched using key words including "*displaced*," "*retrieved*," "*migrated*," or "*accidental*" dental implants. Treatment details were analyzed for the differences between EP and LP in 92 cases from 32 articles published in 13 countries. Statistical significance was evaluated using the Mann-Whitney *U*-test, Fisher's exact test, and Pearson's correlation analysis. **Results:** In the comparison between EP and LP, there was no significant difference in the number of publication countries (11 *vs.* 10), number of published articles (17 *vs.* 15), distributions of cases (50 *vs.* 42), mean age of patients (55.9 ± 1.8 years *vs.* 55.3 ± 2.5 years), male-female distribution (31/19 *vs.* 24/18), and distribution of displacement into the maxillary sinus and other regions (46/4 *vs.* 34/8), and no significant difference in the Pearson's correlation between publication years and the number of articles. DDI retrievals utilized intraoral and endoscopic surgeries (61.2% and 82.5%), transoral and transnasal approaches (93.8% and 81.8%), and local and general anesthesia (64.7% and 76.3%) during EP and LP, respectively. Moreover, significant differences were observed in all distributions between the two factors (30/19 *vs.* 7/33 cases, 30/2 *vs.* 6/27 cases and 2/12 *vs.* 9/29 cases) in EP and LP, respectively ($P < 0.01$). **Conclusions:** These results suggest that most DDI retrievals in otorhinolaryngology since 2018 have been mostly performed using transnasal endoscopic approaches under general anesthesia.

Introduction

Dental implant treatment is widespread worldwide and improves the quality of life (QOL) by enhancing esthetics and restoring the oral function of individuals who have lost their teeth [1,2]. From being just a popular option, dental implants are now considered the global standard for prosthetic rehabilitation of patients with missing teeth [3–10]. On the other hand, most cases of periodontitis are treated by dental implants, and there is increasing use of implants due to the "implant mind"; therefore, the prevalence of peri-implant lesions and diseases is increasing year by year. In recent years, inappropriate approaches and abuse have become a problem in dental implant treatment [11].

The practice of dental implant treatment varies from anatomically and surgically easy to difficult [12,13]. Bone augmentation by socket or sinus lift procedures is often necessary to accommodate dental implants in the maxillary posterior region because of the limited height of available bone. In addition, achieving primary stability of the placed dental implant is difficult when the bone quality of the residual alveolar bone is poor, increasing the risk of dental implant displacement. Therefore, advanced strategies and surgical skills the dental practitioner are of paramount importance [14-19]. Bone augmentation may also be required for dental implant treatment in the posterior mandible with severe alveolar bone resorption [5,20]. This procedure is performed by dental practitioners who have varied experience in dental implant surgery and techniques [16,21,22], suggesting the occurrence of potential complications associated with dental implant surgery. One of the complications, for example, is the displacement or migration of dental implants from their original to ectopic sites [16,23]. Displacement or migration of dental implants occurs primarily during the perioperative period of dental implant surgery, though it can even occur after the placement of dental implant prosthesis [9,16,23-29]. Displaced

* Correspondence: osato-s@giga.ocn.ne.jp

dental implants (DDIs) have been reported to migrate to the paranasal sinuses [10,22,26,30,31], mandibular body [24,32] and canal [33], submandibular space [5], buccal space [34], and even to distant locations, such as the esophagus [35] and stomach [36].

Patients with DDIs not only exhibit localized pain, swelling, discomfort, and/or complications after the surgery, but are also referred to university hospitals on physical and psychological distress [7,10,27,30,37]. Such patients should undergo dental implant removal surgery as soon as possible to prevent further complication [4,5,10,16,19,25,36,38].

Previous reports have mainly discussed the anatomical sites of DDIs and surgical procedures and clinical outcomes of DDI retrieval cases. Based on the reports and reviews of DDI cases, we believe that quantitative evaluation of previously unclear parameters, such as the country of publication, changes in the number of published articles by year, patient background, and treatment details is important. Hence, we decided to conduct comprehensive research on literature published in time frames of limited duration.

The purpose of this study is to evaluate the differences in 10 items regarding DDI cases (the number of publication countries, number of articles, changes in the number of articles, number of cases, age and sex of patients, displaced anatomical sites, treatment techniques, surgical approaches, and anesthesia types) in articles published between 2015–2017 and 2018–2020; and to also analyze the correlation between publication year and number of articles published between 2015 and 2020.

Materials and methods

This meta-analysis has been reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Fig. 1) (http://www.prisma-statement.org/PRISMAStatement/FlowDiagram).

Sources

Four investigators searched the electronic databases of PubMed/MEDLINE, Google Scholar, and ScienceDirect comprehensively for articles pertaining to DDIs published between January 2015 and December 2020. The databases were searched for the following keywords: (“displaced” OR “migrated” OR “accidental” OR “retrieved”) AND “dental implants”

Literature selection and data collection

From the results of this search, four investigators (T.M., S.O., I.M. and Y.N.) excluded literature that did not mention the age and sex of the patients (Tab. I). On the other hand, the evaluation of the periodontal index for the periodontal disease of patients was not included in the selection criteria. Subsequently, only treatment details identified in this study, from available records of each patient, were statistically analyzed. All the selected articles were published in English and comprised case reports, original studies, and systematic reviews. After manually going through the bibliography of the cited articles, all duplicates were removed.

The following 10 items pertaining to the treatment details of patients, shown in Table II, were evaluated: the number of publication countries (a), number of articles (b), changes in the number of articles by year and the correlation between publication year and number of articles published in that year (c), number of cases (d), age (e) and sex (f) of patients, anatomical sites of DDIs (g), treatment techniques (h), surgical approaches (i), and anesthesia types (j). Thereafter, only the definite information provided in the articles pertaining to these items was entered in an Excel spreadsheet (Microsoft Corporation, Redmond, Washington, US), and the total number (n) was calculated as the sample size for each item.

The six years assessed in this study were divided into two periods: 2015–2017 (early phase: EP) and 2018–2020 (late phase: LP). As shown in Table II, two attributes for items (f to j) were provided: sex as male and female, displaced anatomical sites as maxillary sinus (MS) and other regions (OTH), treatment techniques as intraoral surgery (IS) and endoscopic surgery (ES), surgical approaches as transoral approach (TOA) and transnasal approach (TNA), and anesthesia types as local anesthesia (LA) and general anesthesia (GA).

Statistical analysis

The differences between the EP and LP were statistically analyzed for the following nine items. The mean age of patients (item e) was compared using the Mann-Whitney *U*-test. The frequency distribution for items a, b, and d were compared using exact binomial tests. Furthermore, that for items f, g, h, i and j was compared using the Fisher's exact test. For analyzing the association between the publication year and number of articles (item c), the simple correlation coefficient (*r*) was calculated, and statistical significance was determined using Pearson's correlation test. A *P*-value of less than 0.05 was considered to be statistically significant. The software used for statistics was js-STAR version 9.8.7j (Satoshi Tanaka & Nappa [Hiroyuki Nakano], Tokyo, Japan). This software is freely available at www.kisnet.or.jp/nappa/software/star/.

Results

The literature search resulted in 38 articles published across 14 countries with 309 cases (329 implants). In our meta-analysis, we excluded literature that did not describe the age and sex of the patient and finally selected 32 articles published across 13 countries with 92 cases (100 implants) (Tab. I. and Fig. 1). The details of dental implant treatment pertaining to the 10 items included in the articles that met the inclusion criteria are shown in Table I, and the results of statistical analysis are shown in Table II and Figures 2 and 3.

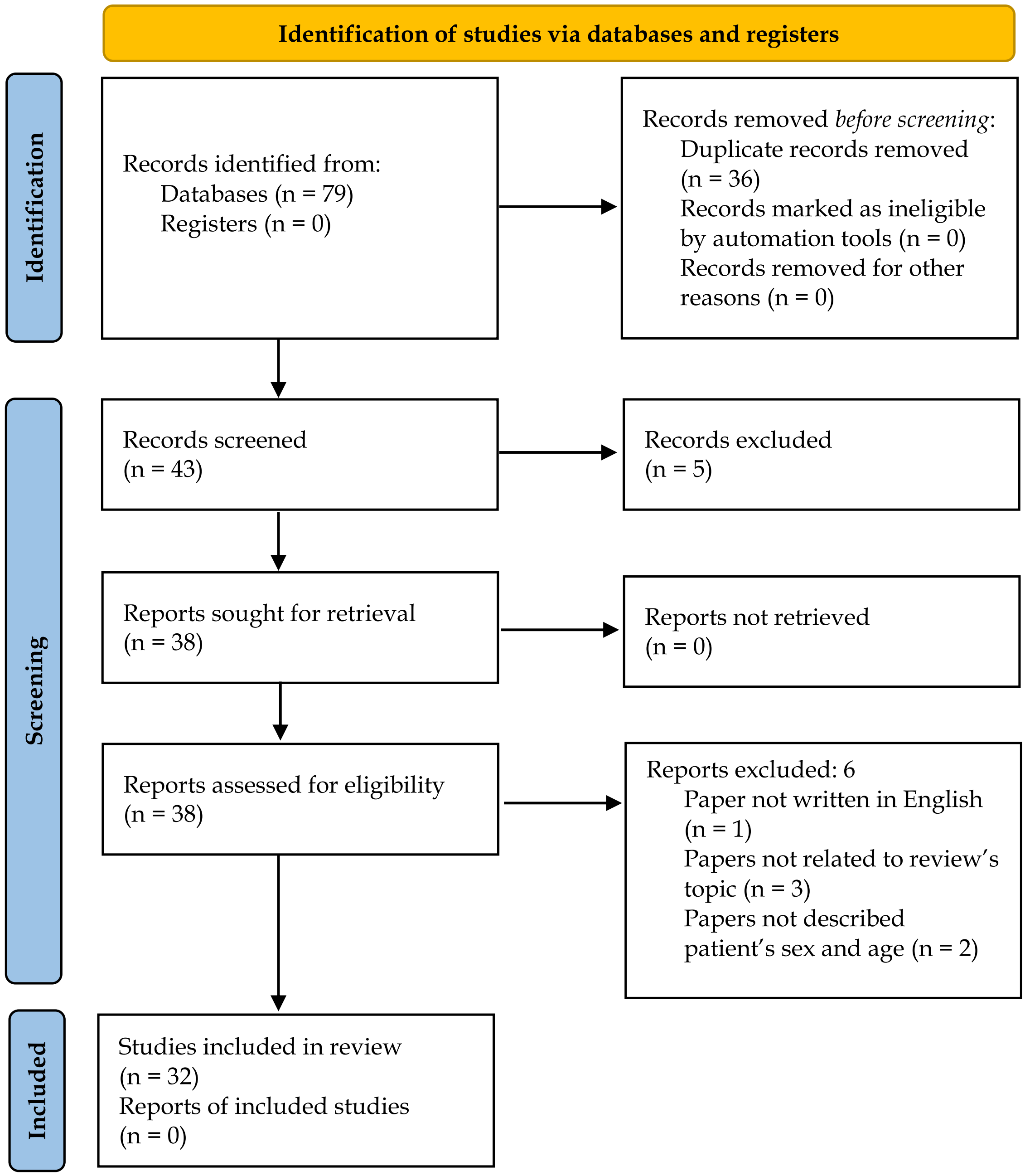

Fig. 1. PRISMA flow chart of the inclusion of case reports, original studies, and systematic reviews.

Number of publication countries and number of articles

Figure 2 shows the number of countries in which the articles were published and the number of articles on DDI cases published in those countries during the study period.

The maximum number of articles was published in Korea (4 and 3 articles) and Italy (3 and 2 articles) in the EP and LP, respectively. In Brazil, one more article was published in the LP than in the EP. In other countries, the number was slightly less or the same in the LP than in the EP.

The number of publication countries (11 [52.4%] *vs.* 10 [47.6%]; *P* = 1.0000) and the number of articles (17 [53.1%] *vs.* 15 [46.9%]; *P* = 0.8601) in the EP and LP were lower in the LP than in the EP, but the differences were not significant (Tabs. IIa. and IIb).

Number of articles by year

Figure 3 shows the changes in the number of articles published from 2015 to 2020, by year. The maximum number of published articles in a year was 8 in 2016 and the minimum

Table I. Detailed treatment record of displaced dental implant cases in 32 articles published from 2015 to 2020.

No.	Authors	Publication year	Country	Case	Age (years)	Sex	Implant	Anatomical sites	Treatment techniques	Surgical approaches	Anesthesia types	Hospital departments
		Early-phase										
1	Bakhshalian *et al.* [26]	2015	Korea	1	60	Male	1	Ethmoid sinus	ES	TOA	GA	OMS
2	Bruniera *et al.* [4]	2015	Brazil	1	60	Female	3	MS	IS	TOA	LA	OMS
3	Ding *et al.* [18]	2015	China	1	65	Female	1	MS	IS	TOA	LA	OMS
4	Sadda [39]	2015	US	1	55	Male	1	MS	IS	TOA	LA	OMS
5	Andreasi Bassi *et al.* [27]	2016	Italy	1	49	Female	1	MS	ES	TOA	LA	ORL*
6	Bibra *et al.* [34]	2016	India	1	54	Male	1	Buccal soft tissue	IS	NC	LA	OMS
7	Cariati *et al.* [5]	2016	Spain	1	66	Male	1	Sublingual space	IS	NC	GA	OMS
8	de Jong *et al.* [30]	2016	Israel	12	NA‡	Male (12)	12	MS (12)	ES (11) and NA† (1)	NA† (1)	NC	ORL
				2		Female (2)	2	MS (2)	ES (2)	NC	NC	
9	Kwon & Pae [32]	2016	Korea	1	NC	Female	1	Mandibular body	IS	NC	NC	OMS
10	Nogami *et al.* [40]	2016	Japan	1	35	Male	1	MS	ES	TOA	LA	OMS
11	Sarmast *et al.* [41]	2016	US	1	71	Female	1	MS	IS	TOA	LA	OMS
12	Sgaramella *et al.* [22]	2016	Italy	10	35–72§	Male (10)	11	MS (10)	IS (10)	TOA (10)	GA (8) and LA (13)	OMS
				11		Female (11)	13	MS (11)	IS (11)	TOA (11)		
13	An *et al.* [42]	2017	Korea	1	63	Male	1	MS	IS	TOA	LA	OMS
14	Brescia *et al.* [37]	2017	Italy	1	40	Male	1	MS	ES	TNA	GA	ORL*
15	Dundar *et al.* [43]	2017	Turkey	1	64	Male	1	MS	ES	NC	NC	OMS
16	Kim [44]	2017	Korea	1	63	Female	1	MS	IS	TOA	LA	OMS
17	Lim *et al.* [45]	2017	Malaysia	1	53	Male	1	MS	ES	TNA	GA	ORL*
	Subtotal			50	35	-	55	50	49	32	34	–
		Late-phase										
18	Gurbanov *et al.* [33]	2018	Turkey	1	51	Female	1	Mandibular canal	IS	NC	LA	OMS
19	Park *et al.* [36]	2018	Korea	1	66	Male	1	Stomach	NA†	NA†	NC	OMS
20	Pistilli *et al.* [24]	2018	Italy	1	57	Female	1	Mandibular body	IS	NC	LA	OMS
21	Dryer & Conrad [46]	2019	US	1	44	Female	1	Pterygoid fossa	ES	TNA	GA	OMS
22	Froum *et al.* [9]	2019	US	1	56	Male	1	MS	IS	TOA	LA	OMS
23	Gnigou *et al.* [16]	2019	Greece	1	73	Male	1	MS	IS	TOA	LA	OMS
				1	55	Female	2	MS	IS	TOA	LA	
24	Jin *et al.* [7]	2019	China	1	72	Male	1	MS	ES	TNA	GA	ORL*
25	Lee *et al.* [31]	2019	Korea	1	57	Male	1	Ethmoid sinus	ES	TNA	NC	ORL
26	Yoon *et al.* [35]	2019	Korea	1	63	Male	1	Esophagus	NA†	NA†	LA	ORL*
27	Chang *et al.* [25]	2020	Taiwan	2	55 and 50	Female (2)	2	MS (2)	ES (2)	TNA (2)	GA (1)	ORL
				1	60	Male	1	MS	ES	TNA	NC	

Table I. (continued).

No.	Authors	Publication year	Country	Case	Age (years)	Sex	Implant	Anatomical sites	Treatment techniques	Surgical approaches	Anesthesia types	Hospital departments
28	Safadi *et al.* [10]	2020	Israel	14	62‖	Male (14)	15	MS (14)	ES (14)	TNA (19) and NC (5)	GA (14)	ORL
				10		Female (10)	10	MS (10)	ES (10)		GA (10)	
29	Dhir *et al.* [19]	2020	India	1	32	Male	1	MS	ES	TOA	LA	OMS
30	Moleta *et al.* [23]	2020	Brazil	1	44	Female	2	MS	IS	TOA	GA	OMS
				1	42	Male	1	MS	IS	TOA	LA	
31	Bocchialini *et al.* [47]	2020	Brazil	1	55	Female	1	Orbit	ES	TNA	GA	ORL*
32	Cascio *et al.* [48]	2020	Italy	1	63	Male	1	Ethmoid sinus	ES	TNA	LA	ORL
	Subtotal			42	18	–	45	42	40	33	38	–
	Total			92	53	–	100	92	89	65	72	–

Abbreviations: ES, endoscopic surgery; GA, general anesthesia including intravenous sedation; IS, intraoral surgery; LA, local anesthesia; MS, maxillary sinus; NA, not available; NC, not clear; OMS, oral and maxillofacial surgery; ORL, otorhinolaryngology, and including a case of collaboration between oral and maxillofacial surgeon and otorhinolaryngologist (ORL*); TNA, transnasal approach; TOA, transoral approach; US, TheUnited States of America; (Parentheses), number of patients and cases. US, The United States of America; TNA, transnasal approach; TOA, transoral approach.* Author's numbers.

† Spontaneously excretion.

‡ Mean age of 14 patients: 54 ± 9.4 years.

§ Range 35–72 years (each age of 21 patients: 58, 50, 56, 62, 55, 45, 65, 47, 47, 59, 35, 63, 67, 59, 72, 70, 39, 59, 49, 36, and 64 years).

This age was excluded from the statistical data due to median age 62 years of 24 patients (range 35-88 years).

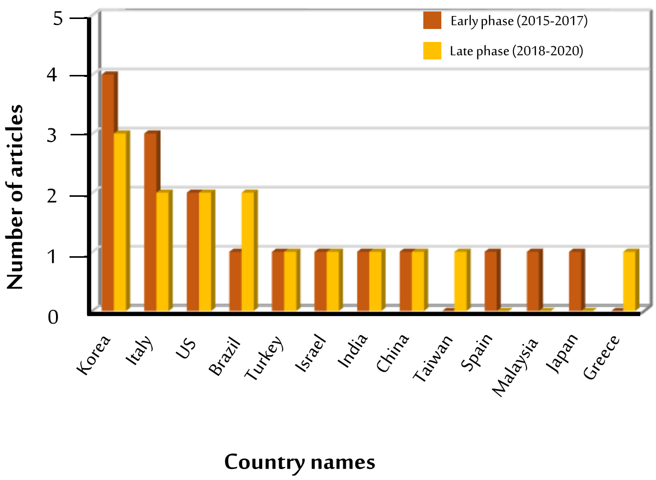

Fig. 2. Number of articles and number of countries that have published articles on displaced dental implant cases reported from 2015 to 2020.

was 3 in 2018. The Pearson's correlation coefficient for the correlation between changes according to year and number of articles was low ($r = 0.06$), and no statistical significance was observed ($P = 0.9157$) (Tab. IIc).

Number of cases

The number of DDI cases was fewer by 8 (8.6%) in the LP (42 cases [45.7%]) than in the EP (50 cases [54.3%]), but the difference in the distributions was not statistically significant ($P = 0.4657$) (Tab. IId).

Age and sex of patients

The mean age of male and female patients was 0.6 years lower in the LP (mean ± standard error [SE], 55.3 ± 2.5 years [95% confidence interval (CI), 50.4–60.1 years]; range, 32–73) than in the EP (mean ± SE, 55.9 ± 1.8 years [95% CI, 52.4–59.3 years]; range, 35–71), but the difference was not statistically significant ($P = 0.7212$). In sex distribution, the number of males (31/50 [62.0%] and 24/42 [57.1%]) was greater than that of females (19/50 [38.0%] and 18/42 [42.9%]) in both the EP and LP. Moreover, male-female distributions (31/19 *vs.* 24/18) between the EP and LP showed no statistically significant differences ($P = 0.6739$) (Tab. IIe and f).

Anatomical sites of the DDIs

The DDIs were mostly reported in the MSs in both the EP and LP, with 46 cases (46/50 [92.0%]) and 34 cases (34/42 [81.0%]) reported in the MSs, respectively. Evidently, fewer cases of dental implant displacement were reported in OTH (including ethmoid sinus, pterygoid fossa, orbit, the mandibular body and canal, esophagus, and other sites) as shown in Table I. Further, the difference in the distribution of cases in the MS and OTH (46/4 *vs.* 34/8 cases) between the EP and LP was not significant ($P = 0.1336$) (Tab. IIg).

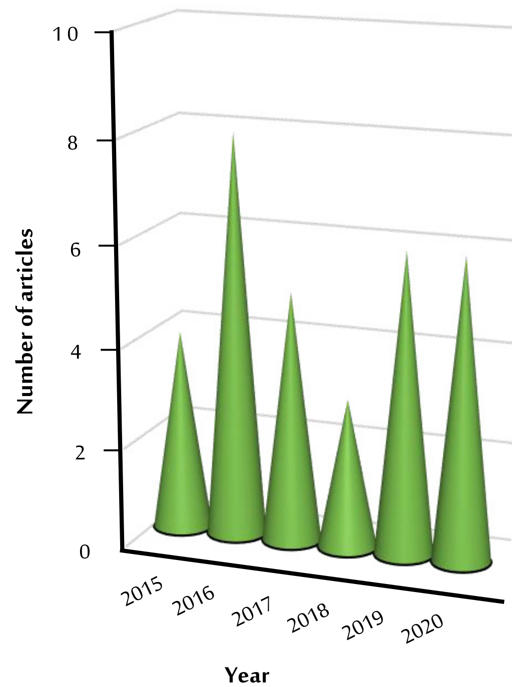

Fig. 3. Changes in the number of articles by year on displaced dental implant cases published over the last 6 years (2015–2020).

Treatment techniques and surgical approaches

The treatment techniques for dental implant placement and surgical approaches used for retrieval of the DDI differed significantly between the EP and LP. IS was mostly used in the EP (30 cases: 30/49 [61.2 %]), whereas ES was mostly used in the LP (33 cases: 33/40 [82.5%]). Additionally, TOA was mostly performed in the EP (30 cases: 30/32 [93.8%]), whereas TNA was mostly performed in the LP (27 cases: 27/33 [81.8%]). The differences in the distributions of cases between the EP and LP in IS and ES (30/19 *vs.* 7/33 cases) and in TOA and TNA (30/2 *vs.* 6/27 cases) were significant, respectively (both $P = 0.0000$) (Tab. IIh and i).

Anesthesia types

The DDIs were mostly retrieved under LA in the EP (22 cases: 22/34 [64.7%]) and GA in the LP (29 cases: 29/38 [76.3%]), and the difference in distributions of cases between EP and LP in LA and GA (22/12 *vs.* 9/29) was statistically significant ($P = 0.0007$) (Tab. IIj).

Discussion

As a result of comparing 10 items regarding DDI cases between the first half of EP (2015–2017) and the second half of LP (2018–2020), significant differences were found in treatment techniques, surgical approaches, and anesthesia types.

In daily clinical practice, with the rapid increase in implant-based reconstruction, the opportunities of encountering complications (mainly infection, postoperative pain, intraoral

Table 2. Comparison of the mean age and frequency distributions between early phase (EP) and late phase (LP) regarding 10 items (a–j) for displaced dental implant articles.

	Research items	Factor	Early-phase	Late-phase	Total	*P*-values
a	Country*		11	10	21	1.0000†
b	Article		17	15	32	0.8601†
c	Articles by year	Correlation‡	Refer Fig. 2		Pearson's $r = 0.06$	0.9157§
d	Case	Males and females	50	42	92	0.4657†
e	Age		n = 35	n = 18	53	
		Mean ± SE	55.9 ± 1.8	55.3 ± 2.5		0.7212‖
f	Sex	Male	31	24	55	0.6739¶
		Female	19	18	37	
g	Anatomical sites	MS	46	34	80	0.1336¶
		OTH	4	8	12	
h	Treatment techniques	IS	30	7	37	0.0000¶
		ES	19	33	52	
i	Surgical approaches	TOA	30	6	36	0.0000¶
		TNA	2	27	29	
j	Anesthesia types	LA	22	9	31	0.0007¶
		GA	12	29	41	

Abbreviations: ES, endoscopic surgery; IS: intraoral surgery; GA: general anesthesia; LA, local anesthesia; MS, maxillary sinus; n, number of patients; OTH, other regions; SE, standard error; TNA: transnasal approach; TOA, transoral approach.
* Duplicate country names were counted as one.
† Exact binomial tests.
‡ Pearson's correlation coefficient (r) between publication year and the number of articles
§ Pearson's correlation test.
‖ Mann–Whitney *U*-test.
¶ Fisher's exact test.
A *P*-value of less than 0.05 was considered to be statistically significant.

hemorrhage, penetration or displacement or dislocation into the maxillary sinus, and neurosensory disturbances) have increased. Dental implant displacement can occur perioperatively, postoperatively, and several years later. In the 32 articles we investigated, 51.1% (47/92 cases) were found perioperatively and 32.6% (30/92 cases) after superstructure placement, and the results were supported by the previous reports [9,16, 23-29].

Jeong *et al.* (2016) [49] reported 22 articles (49 implants) being published in 14 years from 2000 to 2013. In our study period of six years from 2015 to 2020, we found 32 articles and 92 cases (100 implants) in 13 countries. This number is prominently greater than that reported previously. Sgaramella *et al.* (2016) [22] encountered 21 cases in the last 20 years (1990–2010). Gnigou *et al.* (2019) [16] examined the literature reviewed by Sgaramella *et al.* (2016) [22] and found that 14 cases were reported between 2000 and 2010, which were twice as many as had been reported the previous decade (1990–1999). However, they concluded that the accurate incidence of these cases is unknown because of asymptomatic cases and inadequate cohort studies.

No previous article has reported the number of countries where articles pertaining to DDI have been published. In our study duration of six years, the number of articles published was similar between the EP (11 countries) and LP (10 countries), and the number of presentations was 17 articles and 15 articles, respectively, with no significant increase or decrease. The maximum number of articles was published in the Republic of Korea (4 and 3 articles) and Italy (3 and 2 articles) in the EP and LP. In Brazil, the number was more in the LP (2 articles) than in the EP (1 article). However, in other countries, the number was either less or equivalent. Hence, it is necessary to perform additional studies with greater number of cases in the future.

The changes in the number of articles on DDI retrieval, by year, are not well known. The results of this study show that 3 to 8 articles were reported each year between 2015 and 2020, the Pearson's correlation coefficient ($r = 0.06$) between the year and number of articles was low, and no significant association was found. In other words, dental implant practitioners must be aware of the current situation wherein complications pertaining to DDI may occur. Though the number of these cases is less, these aspects must be considered to prevent complications [22,50].

Moreover, previous studies have not compared the number of DDI retrieval cases during two limited periods. In this study, the number of DDI search cases decreased by 8.6% in LP (42 cases [45.7%]) compared to EP (50 cases [54.3%]). One of the reasons for this decrease is that 3D image diagnosis using cone-beam computed tomography (CBCT) imaging is possible, which is considered to be useful for risk aversion [19].

Regarding the average ages of male and female patients with DDI, Chiapasco *et al.* (2009) [38] and Sgaramella *et al.* (2016) [22] reported 55 and 53.9 years, respectively, and they were close to the results of EP (55.9 years) and LP (55.3 years). It was also found that there was no significant difference between patient ages and between the results of EP and LP. Currently, the dental implant treatments have been provided not only to older patients with partially and completely edentulous jaws but also to young adults who have lost one or a few teeth. Some younger patients do have DDIs, and this decreases the mean age.

Pistilli *et al.* (2018) [24] reported that most patients were female. However, our results showed that males were more frequently affected in both the EP and LP (62.0% and 57.1%, respectively) than females, but there was no significant difference in sex distribution, a finding in contrast to their study.

Conventionally, the most frequently reported anatomical site of DDIs is MS [50]. Similarly, in our investigation, both the EP (92.0%) and LP (81.0%) reported same numbers of DDIs in the MS, and no significant difference was observed between the two phases. The factors contributing to DDIs include poor diagnosis, inadequate treatment planning, inadequate experience in surgical procedures, and improper use of surgical instruments [8,26,42]. In addition, loss of maxillary molars increases the pneumatization of MS, leading to insufficient residual bone volume and poor bone quality [3,9,52-54]. Dental implants in the posterior maxilla often show micromovement, and obtaining initial stability is difficult, which leads to a possibility that these dental implants will eventually perforate or migrate into the MS. Occlusal overload may also lead to dental implant displacements. Dental practitioners should accurately assess the sinus morphology and the anatomical structure and variations of the surrounding bone using CBCT while planning dental implant therapy in the posterior maxilla [37,42,49,55].

Regarding the retrieval technique of DDIs, Chang *et al.* (2020) [25] reported four surgical removal techniques. According to our study, IS was used in 61.2% patients in the EP, whereas ES was used in 82.5% patients in the LP, with the differences being statistically significant. So far, the Caldwell-Luc technique or lateral window technique [29] has been reported to cause greater surgical invasion and the occurrence of a postoperative cyst [23,27,49,56,57]. However, ES is less surgically invasive and less likely to cause postoperative cysts [27,58].

Furthermore, when the DDI migrates to or near the inferior or anterior wall of the MS, the prelacrimal recess approach could be used for DDI retrieval, as it provides a panoramic view [27,35,59]. Therefore, the incidence of postoperative facial numbness was lower than that with the Caldwell-Luc technique. Otorhinolaryngologists use the fenestrated approach in the MS or modified transnasal ES by creating a small hole in the inferior nasal meatus [25,60]. Oral and maxillofacial surgeons and otorhinolaryngologists should select safe and minimally invasive surgical procedures for the retrieval of DDIs [7,10,43,44,49].

Dental implants displaced intraoperatively are removed by creating a fenestration in the sinus floor through the alveolar socket and extracting the dental implant using a Klemmer plier or nasal bayonet forceps [38, 45] or aspirated using a suction device. We often use the cupped forceps with a long handle. If a dental implant is displaced days or months after surgery, it can be removed by TOA or TNA according to the patient symptoms [38,45,61].

According to our analytical findings, TOA (93.8%) was mostly used in the EP, whereas TNA (81.8%) was used in the LP, which shows that the treatment technique had changed significantly. Since 2018 (LP), most patients have been referred to the department of otorhinolaryngology at university and specialty hospitals and have undergone surgical removal of DDI (32/42 cases; 76.2%; Tab. 1) [25,29]. Close cooperation between oral and maxillofacial surgeons and otorhinolaryngologists is essential for early and proper patient treatment and to prevent complications [19,23,25,26,38].

Conventionally, LA has been frequently used for the removal of DDIs. We found that LA (64.7%) was mostly used in the EP, and GA (76.3%) was mostly used in the LP. This could be because of the priority given to the safety of the patient during removal surgery, control of patient movement during the surgery, prevention of ectopic migration during inspiration, and the ability to quickly treat discomfort and complications associated with the dental implant placement surgery [22,26,35,36,45,62].

To summarize our findings, over the past 6 years, 32 articles and 92 cases of DDIs have been reported in 13 countries worldwide; of these cases, dislocations or migrations in the MS were predominant. The treatment techniques, surgical approaches, and anesthesia types had changed significantly between 2018–2020 (LP) and 2015–2017 (EP). DDIs are now removed by transnasal approaches under GA in the department of otorhinolaryngology at medical universities and specialty hospitals.

Therefore, to avoid complications, dental practitioners should precisely evaluate the three-dimensional anatomical structure and its variations on CBCT imaging and perform three-dimensional simulations before performing the actual dental implant surgery, and also immediately refer to an experienced specialist if any unanticipated problems occur.

Conclusion

Comparing 2015–2017 (EP) and 2018–2020 (LP), no significant differences were found in the patient's seven background factors (items a–g) regarding DDIs. However, most surgical retrievals in the LP were mostly performed in otorhinolaryngology departments using a transnasal endoscopic approach under GA compared to those in EP (items h–j) since 2018. Therefore, dental practitioners should discuss with their patients that if there is a risk prior to dental implant surgery, they may be referred to an experienced specialist. Results of this analysis need to be validated by using many search engines and comparing them with well-designed studies on this subject with a larger number of cases.

Authors' contributions

T. Miyao: Concept / design, data collection, data analysis / interpretation, drafting article, and approval of article. S. Osato: Concept / design, data collection, statistics, data analysis / interpretation, critical revision of article, responsible for the data analyses, and approval of article. I. Miyao: Data collection, drafting article, and approval of article. Y. Nakajima: Data collection, drafting article, and approval of article. M. Shirakawa: Data analysis / interpretation, critical revision of article, and approval of article.

Conflict of interest

The authors declare that they have no conflicts of interest in relation to this article.

Informed Consent

The authors declare that informed consent not required.

Ethical committee approval

The authors declare that Ethical approval not required.

Source of funding

This research did not receive any specific funding.

Acknowledgements. We would like to thank Ms. Kyoko Fujii, for her cooperation with the submission of the article. We also thank the late Dr. Iwao Kuroyama who passed away on October 31, 2020 (WCOI Secretary-General) and Dr. Shogo Shioji (WCOI Board Director) for their advices regarding the research design.

References

1. Bugone É., Vicenzi C.B., Cardoso M.Z., Berra L., de Carli J.P., Franco A., et al. The impact of oral rehabilitation with implants in nutrition and quality of life: a questionnaire-based survey on self-perception. J Clin Exp Dent 2019;11:e470–e475.
2. Wang Y., Fan Y., Lin Z., Song Z., Shu R., Xie Y. Survival rate and potential risk indicators of implant loss in non-smokers and systemically healthy periodontitis patients: an up to 9-year retrospective study. J Periodontal Res 2021;56:547–557.
3. Elani H.W., Starr J.R., Da Silva J.D., Gallucci G.O. Trends in dental implant use in the U.S., 1999-2016, and projections to 2026. J Dent Res 2018;97:1424–1430.
4. Bruniera J.F., Silva-Sousa Y.T., Faria P.E. A typical case of three dental implants displaced into the maxillary sinus. Case Rep Dent 2015;2015:896423.
5. Cariati P., Fernández-Solís J., Marín-Fernández A.B., Valencia-Laseca A., Monsalve-Iglesias F. Accidental displacement of a dental implant into the sublingual space: a case report. J Clin Exp Dent 2016;8:e459–e461.
6. Buser D., Chappuis V., Belser U.C., Chen S. Implant placement post extraction in esthetic single tooth sites: when immediate, when early, when late? Periodontol 2000 2017;73:84–102.
7. Jin T., Wang Y., Li S., Cai Q., Huang Z. Removal of the dental implant displaced into the maxillary sinus through the inferior nasal meatus via transnasal endoscopy. J Craniofac Surg 2019;30:1178–1179.
8. Romanos G.E., Bastardi D.J., Moore R., Kakar A., Herin Y., Delgado-Ruiz R.A. In vitro effect of drilling speed on the primary stability of narrow diameter implants with varying thread designs placed in different qualities of simulated bone. Materials (Basel) 2019;12:1350.
9. Froum S.J., Elghannam M., Lee D., Cho S.C. Removal of a dental implant displaced into the maxillary sinus after final restoration. Compend Contin Educ Dent 2019;40:530–535.
10. Safadi A., Ungar O.J., Ozi, I., Koren, I., Abergel, A., Kleinman, S. Endoscopic sinus surgery for dental implant displacement into the maxillary sinus: a retrospective clinical study. Int J Oral Maxillofac Sur 2020:49;996–999.
11. Matarese G., Ramaglia L., Fiorillo L., Cervino G., Lauritano F., Isola G. Implantology and periodontal disease: the panacea to problem solving? Open Dent J. 2017;11:460–465.
12. Gibson R.L., Barclay C.W. Dental implantology education: a survey of opinion and experience of 106 general dental practitioners. Br Dent J 2006;201:367–370.
13. Eswaran, M.A., Rai R., Husain S., Saravanan R., Kesavan R. Knowledge, Awareness and practice of implant placement among general dental practitioners and implant specialists. WJPLA 2019;5:159–163.
14. Mudalal M., Sun X.L., Li X., Fang J., Qi M.L., Wang J., Du L.Y., Zhou Y.M. Minimally invasive endoscopic maxillary sinus lifting and immediate implant placement: a case report. World J Clin Cases 2019;7:1234–1241.
15. Al-Dajani M. Recent trends in sinus lift surgery and their clinical implications. Clin Implant Dent Relat Res 2016;18:204–212.
16. Gnigou M., Goutzanis L., Sarivalasis S., Petsinis V. Retrieval of displaced implants inside the maxillary sinus: two case reports and a short review. Int J Implant Dent 2019;5:24:1–8.
17. Bhalla N., Dym H. Update on maxillary sinus augmentation. Dent Clin North Am 2021;65:197–210.
18. Ding X., Wang Q., Guo X., Yu Y. Displacement of a dental implant into the maxillary sinus after internal sinus floor elevation: report of a case and review of literature. Int J Clin Exp Med 2015;8:4826–4836.
19. Dhir V., Saini S., Rao S., Padha K. Successful retrieval of dental implant from maxillary sinus by interdisciplinary approach in a high altitude as a complication during prosthetic phase: a rare case report. J Dent Def Sect 2020;14:92–95.
20. Nielsen H.B., Starch-Jensen T. Lateral ridge augmentation in the posterior part of the mandible with an autogenous bone block graft harvested from the ascending mandibular ramus. A 10-year retrospective study. J Stomatol Oral Maxillofac Surg 2021;122:141–146.
21. Lambert P.M., Morris H.F., Ochi S. Positive effect of surgical experience with implants on second-stage implant survival. J Oral Maxillofac Surg 1997;55(12 Suppl 5):12–18.

22. Sgaramella N., Tartaro G., D'Amato S., Santagata M., Colella G. Displacement of dental implants into the maxillary sinus: a retrospective study of twenty-one patients. Clin Implant Dent Relat Res 2016;18:62–72.
23. Moleta A., Brasil L.M., de Oliveira E.R., Weiss S.G., Gontarz D., de Sant'ana, R.D., et al. Conservative technique for the removal of implants displaced into maxillary sinus. RSBO 2020;17: 69–75.
24. Pistilli V., Checchi V., De Paolis F., Pistilli R., Barausse C. Displacement of a dental implant in the mandible body: an unusual case report. Eur J Oral Implantol 2018;11:235–240.
25. Chang P.H., Chen Y.W., Huang C.C., Fu C.H., Huang C.C., Lee T.J. Removal of displaced dental implants in the maxillary sinus using endoscopic approaches. Ear, Nose & Throat Journal 2020;1–4.
26. Bakhshalian N., Sim Y.C., Nowzari H., Cha H.S., Ahn K.M. Accidental migration of a dental implant into the ethmoid sinus following a transalveolar sinus elevation procedure. Clin Implant Dent Relat Res 2015;17:360–364.
27. Andreasi Bassi M., Andrisani C., Lico S., Ormanier Z., Arcuri C. Endoscopic retrieval of a dental Implant into the maxillary sinus: a case report. Oral Implantol (Rome) 2016;9:69–75.
28. Guler N., Delilbasi C. Ectopic dental implants in the maxillary sinus. Quintessence Int 2007;38:e238–e239.
29. Laureti M., Ferrigno N., Rosella D., Papi P., Mencio F., De Angelis F., et al. Unusual case of osseointegrated dental implant migration into maxillary sinus removed 12 years after insertion. Case Rep Dent 2017;2017:9634672.
30. de Jong M.A., Rushinek H., Eliashar R. Removal of dental implants displaced into the maxillary sinus: a case series. Eur J Oral Implantol 2016;9:427–433.
31. Lee T.Y., Zaid W.S. Broken dental needle retrieval using a surgical navigation system: a case report and literature review. Oral Surg Oral Med Oral Pathol Oral Radiol 2015;119:e55–59.
32. Kwon Y.D., Pae A. Piezoelectric trapezoidal osteotomy for the retrieval of a displaced dental implant in the osteoporotic mandibular body. Implant Dent 2016;25:703–706.
33. Gurbanov V., Torul D., Kazan D. Retrieval of an unusually displaced implant with healing cap into the mandibular canal. J Oral Implantol 2018;44:341–343.
34. Bibra A., Mahajan S., Dhawan R. Retrieval of dental implant displaced into buccal space: a rare case report. Int J Oral Implantol Clin Res 2016;7:17–19.
35. Yoon S.H., Jung S., Kang T., Yang H.C. Accidental swallowing of dental implant: Complication of transnasal endoscopic removal from maxillary sinus. J Oral Implantol 2019;45:219–222.
36. Park J.H., Kim H.Y., Kim S.J. From the maxillary sinus to the stomach: A rare case report of a displaced fragment of dental implant. Eur J Oral Implantol 2018;11:469–473.
37. Brescia G., Saia G., Apolloni F., Marioni G. A novel nasal endoscopic approach for removing displaced dental implants from the maxillary sinus. Am J Otolaryngol 2017;38:92–95.
38. Chiapasco M., Felisati G., Maccari A., Borloni R., Gatti F., Di Leo F. The management of complications following displacement of oral implants in the paranasal sinuses: a multicenter clinical report and proposed treatment protocols. Int J Oral Maxillofac Surg 2009;38:1273–1278.
39. Sadda R. Crestal approach for removing a migrated dental implant from the maxillary sinus: a case report. Gen Dent 2015;63:78–79.
40. Nogami S., Yamauchi K., Tanuma Y., Odashima K., Matsui A., Tanaka K., et al. Removal of dental implant displaced into maxillary sinus by combination of endoscopically assisted and bone repositioning techniques: a case report. J Med Case Rep 2016;10:1.
41. Sarmast N.D., Wang H.H., Ma R., Carrion J.A., Iacono V.J. Retrieval of displaced implant attributable to an ill-fitting denture from the maxillary sinus six months after transcrestal sinus floor augmentation and implant placement. Clin Adv Periodontics 2016;6:175–181.
42. An J.H., Park S.H., Han J.J., Jung S., Kook M.S., Park H.J., et al. Treatment of dental implant displacement into the maxillary sinus. Maxillofac Plast Reconstr Surg 2017;39:35.
43. Dundar S., Karlidag T., Keles E. Endoscopic removal of a dental implant from maxillary sinus. J Craniofac Surg 2017;28:1003–1004.
44. Kim S.M. The removal of an implant beneath the optic canal by modified endoscopic-assisted sinus surgery. Eur Arch Otorhinolaryngol 2017;274:1167–71.
45. Lim D., Parumo R., Chai M.B., Shanmuganathan J. Transnasal endoscopy removal of dislodged dental implant: a case report. J Oral Implantol 2017;43:228–231.
46. Dryer R.R., Conrad H.J. Displacement of a dental implant into the pterygoid fossa: a clinical report. J Prosthodont 2019;28:1044–1046.
47. Bocchialini G., Negrini S., Bolzoni Villaret A., Pianta L. Intraconal orbital displacement of a dental implant treated with an endoscopically-assisted approach. Br J Oral Maxillofac Surg 2020;58:469–471.
48. Cascio F., Basile G.A., Debes Felippu A.W., Debes Felippu A.W., Trimarchi F., Militi D., et al. A dental implant dislocated in the ethmoidal sinus: a case report. Heliyon 2020;6:e03977.
49. Jeong K.I., Kim S.G., Oh J.S., You J.S. Implants displaced into the maxillary sinus: a systematic review. Implant Dent 2016;25:547–551.
50. Yamashita Y., Iwai T., Hirota M., Omura S., Aoki N., Tohnai I. Removal of migrated dental implants from maxillary sinus 4 years 10 months after implant placement. Oral Maxillofac Surg 2015;19:315–319.
51. Wojtera B., Wozna A., Komisarek, O. The management of foreign body displacement into the maxillary sinus as a complication of maxillofacial interventions: systematic review. Indian J Otolaryngol Head Neck Surg 2020[r1].
52. Cavalcanti M.C., Guirado T.E., Sapata V.M., Costa C., Pannuti C.M., Jung R.E., et al. Maxillary sinus floor pneumatization and alveolar ridge resorption after tooth loss: a cross-sectional study. Braz Oral Res 2018;32:e64.
53. Alqahtani S., Alsheraimi A., Alshareef A., Alsaban R., Alqahtani A., Almgran M., et al. Maxillary sinus pneumatization following extractions in Riyadh, Saudi Arabia: a cross-sectional study. Cureus 2020;12:e6611.
54. Hamdoon Z., Mahmood N., Talaat W., Sattar A.A., Naeim K., Qais A., et al. Evaluation of different surgical approaches to remove dental implants from the maxillary sinus. Sci Rep 2021;11:4440.
55. Nunes L.S., Bornstein M.M., Sendi P., Buser D. Anatomical characteristics and dimensions of edentulous sites in the posterior maxillae of patients referred for implant therapy. Int J Periodontics Restorative Dent 2013;33:337–345.
56. Ramotar H., Jaberoo M.C., Koo Ng N.K., Pulido M.A., Saleh H.A. Image-guided, endoscopic removal of migrated titanium dental implants from maxillary sinus: two cases. J Laryngol Otol 2010;124:433–436.
57. Niederquell B.M., Brennan P.A., Dau M., Moergel M., Frerich B., Kämmerer P.W. Bilateral postoperative cyst after maxillary sinus surgery: report of a case and systematic review of the literature. Case Rep Dent 2016;2016:6263248.

58. Park W.B., Kim Y.J., Han J.Y., Kang P. Successful management of dental implants in postoperative maxillary cyst: a case report with a 13-year follow-up. J Oral Implantol 2020;46:133–138.
59. Zhou B., Han D.M., Cui S.J., Huang Q., Wang C.S. Intranasal endoscopic prelacrimal recess approach to maxillary sinus. Chin Med J. (Engl) 2013;126:12761-21280.
60. Manfredi M., Fabbri C., Gessaroli M., Morolli F., Stacchini M. Surgical fenestrated approach to the maxillary sinus like alternative to Caldwell-Luc technique. Minerva Stomatol 2019;68:308–316.
61. Li S., Xing Z., Yu L. Accidental migration of a dental implant into the nasal cavity. J Int Med Res 2020;48:300060520948736.
62. Yoshida K., Shoji H., Osato S. Retrieval of displaced dental implant: a case of buccal space displacement and an analysis of the literature search (2015–2019). Advances in Oral and Maxillofacial Surgery 2021;1:100001.