

Two-Center Observational Case Series Describing Decay Adjacent to Fixed Implant Restorations (DATFIR) and Evaluation of Case Parameters

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Abstract: Aim: To describe *Decay Adjacent to Fixed Implant Restoration* in a retrospective case series and evaluate patterns of case parameters associated with this complication.

Materials and Methods: This observational study collected and described 56 cases of proximal tooth *decay adjacent to fixed implant restoration* (termed DATFIR) from a convenience sample of implants placed and followed at two referral based surgical centers, restorations were done by a general dental practices in referral area. The following parameters were evaluated; time in service, patient age and sex as well as site related parameters such as implant location in jaw, decay at mesial or distal of implant, interproximal contact loss, presence of a prior restoration on tooth that developed decay, and faulty margin on implant restoration.

Results: There were 56 sites of DATFIR in 46 patients. The time from implant placement to the time that decay was observed was on average 4.1 years. Teeth mesial to implant were more often involved with 44 mesial sites with DATFIR versus 12 distal sites. Posterior sites of DATFIR greatly outnumbered anterior sites at 55:1. The following "other parameters" were also evaluated. There were 13 sites where DATFIR developed in the presence of an open contact (ICL) and these were all sites where decay developed on the tooth mesial to the implant. There were 17 sites where DATFIR developed as recurrent decay on teeth with a prior restoration. There were 5 sites where DATFIR developed and there was an open margin noted on the implant crown.

Conclusion: DATFIR complication was observed most often on posterior teeth 3 to 5 years following implant placement and typically at the tooth mesial to the implant. The DATFIR complication also occurred often at sites of a previously restored tooth, sites of ICL, and open margins on implant restoration. A discussion between patient and clinician about this complication should be included as part of pre-operative informed consent and patients may also warrant more caries prevention strategies and closer follow up in certain cases.

Keywords: Dental implant, complications, decay, contact loss, food trap, case series.

1. INTRODUCTION

A dental implant supported restoration is a highly predictable method for replacing missing teeth. Modern implant designs, in particular, have high overall survival rates of over 95% at 5-10 years [1]. However, there remain technical, biological, and aesthetic complications, where up to 20% of implants have the potential for complication by 5 years, and of this, 7.1% are biological. The most common biologic complication is progressive marginal bone loss [2, 3]. Another potential biologic complication, more recently acknowledged, is decay affecting natural teeth adjacent to a fixed implant restoration, however this potential complication has received minimal attention in the literature [4].

The original application of implants was primarily for edentulous patients [5,6]. Since the early, fully edentulous applications were proven successful, dental implants and abutment designs were then modified to allow replacement teeth in partially dentate patients. Partially dentate patients outnumber fully edentulous patients 4:1 with 120 million Americans versus 36 million, respectively, such that nowadays the majority of implant placement is in partially dentate patients [7]. Therefore, complications relating to natural teeth when adjacent to dental implants must be kept in mind when treating and maintaining implants in partially edentulous patients.

When implant supported restorations are placed between natural teeth, one complication reported is food impaction. This is in part due to the contour of the restoration, given the narrow implant base relative to crown dimension, in particular with a single fixture in a molar application. This may be further aggravated by a

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loss of proximal contact between the implant restoration and the adjacent tooth. This is termed "interproximal contact loss" (ICL) and is a common finding reported at 52% of implant sites [8]. Due to either overhang or food trapping, teeth adjacent to implant restorations may be prone to plaque accumulation and altered local microbial flora, which may increase decay risk.

Implants have an implant abutment interface (IAI), and in some cases, a crown-abutment interface. The microgap at the IAI is well established and it is known that this interface is colonized by bacteria. In the case of one stage systems, such as Tissue Level implants, the crown margin is the microgap [9,10]. It is possible that this microbial concentration has the potential to alter local flora and may predispose the adjacent tooth to decay at level of root surface or proximal enamel. Also, if there is a poor margin fit on the implant restoration it may further enhance decay risk. Lastly, if the adjacent tooth has a prior restoration, the type of material used may play a role in decay. This is seen by reports that composite resin may increase the risk for proximal decay since it lacks the ability to increase the local pH, therefore promoting a more acidogenic biofilm [11,12].

Despite the aforementioned potential, there remains very few reports in the literature regarding proximal decay at teeth adjacent to an implant restoration. One of the few is a multicenter retrospective study of 1,365 single posterior implant crowns surrounded by natural teeth followed over a 1- to 10-years and reporting interproximal decay at 129 adjacent teeth for a rate of 5% [4]. However, the 5% rate may not apply evenly to all cases or sites and so warrants further evaluation as the parameters where decay adjacent to an implant restoration is observed more or less often. There is also tooth loss, as an indirect measure of decay, as reported in a retrospective clinical study that found teeth mesial to an implant restoration were at double the risk for tooth loss at a rate of 5.73%, as compared to 2.59% tooth loss for opposing control teeth [31]. Given the limited publications to date, the overall frequency of this complication is as yet not well known and furthermore, as to whether the presence of an implant increases the risk for adjacent decay is also not known and would require controlled or comparative studies.

The purpose of this report is to further the knowledge base and describe "*Decay Adjacent to Fixed Implant Restoration*" (hereafter termed DATFIR)

in a retrospective case series and to evaluate patterns and parameters more often associated with DATFIR, such that it may assist future recognition and studies on this topic.

2. METHODS AND MATERIALS

This two center observational study describes cases of proximal tooth *decay adjacent to fixed implant restoration* (DATFIR). Center one (DF) collected data on cases of DATFIR from a convenience sample of 10,400 placed in private surgical practice between 01-03-1999 and 01-12-2016 by one periodontist (DF) Calgary, Alberta, Canada using surgical principles/protocol as described in the previously published survival analysis [1]. Restoration of implants for Center 1 were completed by a variety of General Dentists and Specialists in the Calgary region and included single crowns as well as multiple-unit fixed prosthesis with splinted implants. Center 1 searched key term "decay" from electronic patient files then retrieved cases where DATFIR was identified as an incidental finding at implant recall maintenance visit. Center 2 (JL) reviewed from paper files and compiled a convenience sample of cases with DATFIR complication from 3005 implants placed in the surgical center (JL) and then restored by a variety of general dental practices in Edmonton, Alberta, Canada.

All patients were provided informed consent and implant therapy provided according to regional standard of care. The cases of DATFIR were then compiled from both centers with unique identifier and the following were then evaluated; time in service, patient related parameters, and site related parameters. This retrospective observational report has obtained Ethics Approval # Pro00080055 from the University of Alberta, Canada. The time that the implant was placed, to the time that decay was noted at recall, marks the time in service to DATFIR. Patient related parameters included factors such as age, sex, and xerostomia. Site related parameters included factors such as location of decay relative to implant (mesial or distal), implant site in arch, interproximal contact loss (= ICL), if there was a prior restoration on the tooth that developed decay (= Prior) and if there was an open or faulty margin as noted on radiograph implant restoration (= margin). For the purpose of this paper, anterior implant sites included FDI = 1 to 3 and posterior implant sites included FDI = 4-8. Also for the purpose of this paper, "prior" restoration represented any restoration, thus included crowns, onlays, inlays, direct and indirect composites, and amalgams. If no

site related risk conditions were noted then it was recorded as "None". Site related risk considerations were listed in right column of Table 1 as ICL, Prior, Margin, and None. If more than one of these conditions were present both were recorded.

The missing or excluded cases were as follows: i) cases not yet restored, ii) not yet due for first year recall after restoration, iii) "drop-outs" that did not return for any post-prosthetic recall, iv) implant supported dentures or full arch fixed or hybrid prosthesis, v) implant to implant splinted connections in partial edentulous patients. Also missing from this report is teeth adjacent to an implant that were extracted, since the cause of extraction was not recorded but may have included decay or periodontal causes. Both centers (DF) and (JL) were surgical centers performing implant recall for bone and soft tissue whereas restorative recalls were completed at restorative offices. This case series included only cases of decay noted as an incidental finding at surgical recall, if DATFIR was noted and restored at the general restorative office then this was also not included.

3. RESULTS

A full listing of cases in this series and parameters evaluated is described in Table 1.

Center 1 retrieved 49 sites from 39 patients where DATFIR was identified as an incidental finding at implant recall maintenance visit. Center 2 (JL) compiled 7 sites in 7 patients. Overall this report described 56 cases of decay on natural teeth that were adjacent an implant in 46 patients. It was observed that the decay was often rapid and, in some cases, led to the loss of the tooth.

It was also observed that 10 patients had more than one DATFIR event in different sites of the mouth.

3.1. Time in service to DATFIR

The time that the implant was placed, to the time that decay was noted at recall, marks the time in service to DATFIR. The time in service to DATFIR within this case series ranged from 1 to 15 years. The mean, median, and mode were 4.1, 3, and 3 years, respectively.

3.2. Patient Related Parameters

3.2.1. Age

The age of the individuals at the time the decay was first observed ranged from ages 37 to 80 years old.

The mean, median, and mode were 62.5, 61.5, and 58 years, respectively.

3.2.2. Sex

Out of the 46 individuals in whom DATFIR complication was observed 26 were female and 20 were male.

3.3. Site Related Parameters

3.3.1. Mesial, Distal

Out of the 56 sites, DATFIR was noted mesial to the implant in 44 sites compared to 12 distal sites.

3.3.2. Implant Location

There were 25 mandibular sites of DATFIR and 31 maxillary sites of DATFIR.

There was 1 anterior implant site compared to 55 posterior implant sites where DATFIR complication occurred.

3.3.3. Other Parameters

The following "other parameters" were also evaluated on each case; ICL Prior, Margin & None as described in the methods section.

- There were 13 sites where DATFIR developed in the presence of an open contact (ICL) and these were all sites where decay developed on the tooth mesial to the implant.
- There were 17 sites where DATFIR developed as recurrent decay on teeth with a prior restoration.
- There were 5 sites where DATFIR developed and there was an open margin noted on the implant crown.
- There were 11 sites where DATFIR developed when "None" was recorded as such decay developed when there was no prior restoration on tooth, no open margin at implant crowns, and no ICL.

These are described in the right column of Table 1 and visually described with sample cases with various parameters are shown in Figures 1 through 9.

4. DISCUSSION

This report describes 56 sites of decay on natural teeth that are adjacent an implant in 46 subjects. The

Table 1: DATFIR Case Series Description

Patient level N=	Implant level N=	Unique Identifier	Age	Sex	Implant site (FDI #)	Mesial, Distal from Implant	Time in service to decay (years)	Other parameters	Figures
1	1	DF1	62	F	36	M	8	none	
2	2	DF2	51	F	35	M	5	none	
3	3	DF3	57	M	46	M	4	Prior	
	4				24	M	4	ICL	
4	5	DF4	49	F	24	D	8	none	
5	6	DF5	72	M	24	M	9	ICL	
	7				15	M	3	ICL	Figure 1
6	8	DF6	71	F	24	M	3	margin	Figure 2
	9				46	M	5	ICL	
7	10	DF7	68	F	47	M	11	none	
	11				15	D	2	margin	
	12				17	M	5	Prior	
8	13	DF8	77	M	44	M	15	ICL	Figure 3
9	14	DF9	78	M	24	M	6	margin	
	15				14	M	3	none	
10	16	DF10	62	M	26	M	6	prior	
	17				47	M	2	ICL, prior	
11	18	DF11	49	F	14	M	7	Prior	Figure 4
12	19	DF12	55	F	16	M	3	none	
13	20	DF13	73	F	36	M	4	none	
14	21	DF 14	69	F	36	M	5	ICL	
15	22	DF 15	76	M	24	M	4	ICL	
16	23	DF16	79	F	24	M	7	Prior	
17	24	DF17	65	F	36	M	3	ICL, Prior	Figure 5
18	25	DF18	52	M	31	D	7	Prior	
19	26	DF19	48	F	36	M	6	Prior	
20	27	DF20	52	F	14	M	4	Prior	
21	28	DF21	64	M	47	M	2	Prior	Figure 6
22	29	DF22	71	M	45	M	7	ICL	
23	30	DF23	58	F	25	D	4	Prior	
24	31	DF24	37	F	45	M	4	ICL, Prior	
	32				16	M	4	Prior	
25	33	DF25	58	M	16	D	2	Prior	
26	34	DF26	55	M	15	M	3	ICL, Prior	
27	35	DF27	54	M	46	M	2	ICL	Figure 7
28	36	DF28	60	F	36	D	5	Prior	
29	37	DF29	54	F	26	D	3	Prior	
30	38	DF30	79	M	25	D	3	Prior	
31	39	DF31	77	F	36	M	2	ICL, Prior	Figure 8
32	40	DF32	61	M	15	M	1	Prior	
33	41	DF33	69	F	16	D	2	Prior	
	42				26	D	2	Prior	
34	43	DF34	61	M	16	M	1	Prior	
35	44	DF35	59	M	37	M	1	ICL, Prior	
36	45	DF36	80	M	26	D	3	Prior	
	46				14	M	3	Prior	
37	47	DF37	50	M	46	M	2	ICL	
38	48	DF38	58	F	46	M	3	none	
39	49	DF39	67	M	26	M	2	none	
40	50	JL1	72	F	16	M	3	Prior	
41	51	JL2	59	F	36	M	4	ICL, Prior	
42	52	Jl3	41	F	47	M	2	none	Figure 9
43	53	JL4	68	F	16	M	2	ICL, Margin	
44	54	JL5	76	F	25	M	2	ICL Prior	
45	55	JL6	63	F	46	M	3	none	
46	56	JL7	61	M	46	D	2.5	ICL, Margin	



Figure 1: ICL, No Prior Restoration.

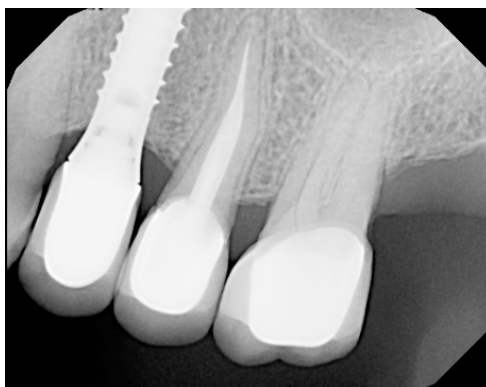


Figure 2: Open Margin at Implant Crown.

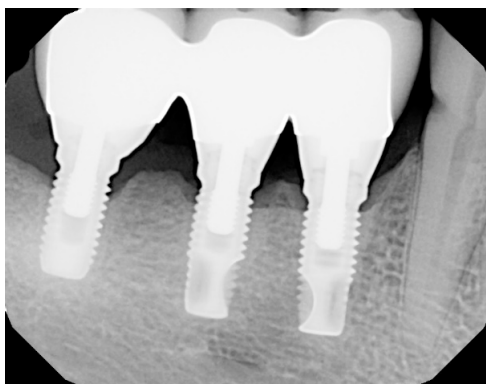


Figure 3: ICL, No Prior Restoration.



Figure 4: Prior Restoration, Rapid Decay.

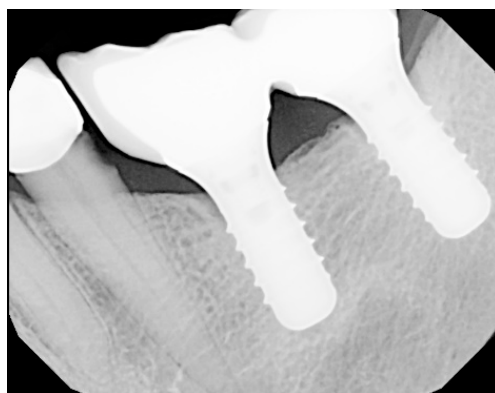


Figure 5: ICL and Prior Restoration.



Figure 6: No ICL, Prior Restoration.

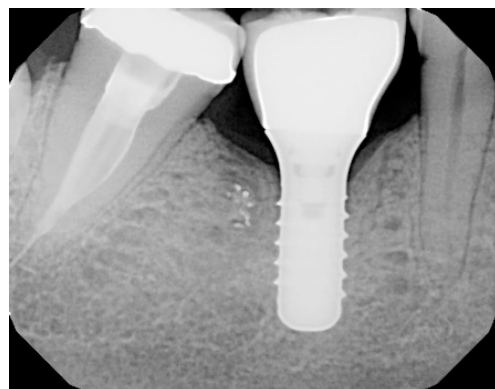


Figure 7: ICL, No Prior, Early Decay.

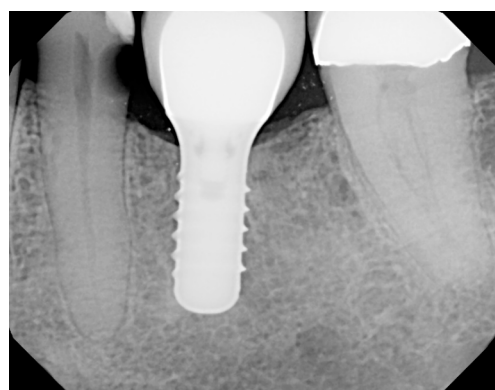


Figure 8: ICL, Prior Restoration, Rapid.



Figure 9: No ICL or Prior restoration. Rapid.

decay was often rapid and in some cases catastrophic leading to the loss of the tooth. Dental implants are often chosen to protect the adjacent teeth from unnecessary reduction that would otherwise be done if a bridge were planned. It is therefore concerning that this potential complication can lead to severe, non-restorable decay or tooth loss. There is one study that suggests the risk for decay development on adjacent sties is up to 5% [4]. Nonetheless, even if the frequency of this complication is 5% it may well be protective to the adjacent tooth versus reduction for conventional fixed bridge since as discussed in their report abutment tooth decay in fixed prosthesis approximates 20% [4,14].

4.1. Time in Service to Decay

The time from implant placement to the time that decay had a wide range, from 1 to 15 years within this case series. The majority of the observed cases fell within the short to medium term timeframe after implant placement, generally within 3 to 5 years. This may also be a function of the scheduled maintenance recall at a surgical office, which is typically at 1, 3, and 5 years post-implant insertion, unless additional follow up was required. However, whether it is 1-2 years or over 10 years after restoration, it was observed teeth adjacent to implant restorations are at both short and long term risk for decay and therefore require regular and long term observation for prevention and early intervention as required.

4.2. Patient Related Considerations

It was observed that 10 of the 46 patients had more than one decay occurrence on teeth adjacent implants which suggests that some patients with a history of decay adjacent to implant are more prone to decay at other sites. Although no conclusion can be drawn since this report did not evaluate each patient as to DMF

score. A DMF assessment may be warranted in future studies of DATFIR to provide an indication as to whether a patient is at risk for developing this complication. It is possible that a high DMF score patient is at greater risk for developing DATFIR.

The age of patient at time of decay had a broad range but the average was over 60 years of age. It is known that salivary function and buffering capacity reduces with age. It is also affected by chronic medical conditions and certain medications that are more prevalent in older patient populations [15,16]. In this report, there was one patient with Sjogrens syndrome as a contributing medical factor and in this case the patient had multiple incidences of decay on teeth adjacent to implant restorations. Age and diseases of age may play a role in risk determination for decay on adjacent teeth, but in this report, since there was no control or comparison group, no conclusion could be drawn as to the effect of age on DATFIR. However, since an elderly patient group is at a greater risk overall for proximal or root decay, these may warrant special attention and follow up.

The sex of the patient did not seem to affect the risk for DATFIR as it was relatively evenly distributed. Although in this report a comparison of total cohort for male female distribution was not done, a previous study reporting on DF cohort noted implants were evenly distributed in male and female subjects and this served as a proxy on relative male female distribution for the current study. Since there was an even distribution of decay in male and female subjects it may suggest that bite force is not a significant factor in the development of DATFIR since males typically have higher bite forces [17]. This is interesting, especially in relation to ICL and food entrapment phenomenon, and thus may indirectly suggest that ICL development and decay risk is not related to bite force.

4.3. Site Related Parameters

The overall patient pool was not calculated as to number of implants in maxillary versus mandibular positions nor anterior versus posterior so relative rates were not calculated. Nonetheless, the distribution DATFIR complication maxilla versus the mandible was fairly even. Whereas, posterior implants with the DATFIR complication outnumbered anterior implants with the DATFIR complication by 55 to 1 respectively. This phenomenon could be explained due to the width of a dental implant, typically 4 to 5mm, which may lead to an unavoidable overhang contour, especially when restoring a typical molar of 9 to 11mm mesio-distal space. This may lead to potential for food entrapment at the gingival third of the implant. This can be further aggravated by the high prevalence of ICL 50% of implant restorations demonstrated ICL and where food impaction was reported by 40% of subjects [8]. Furthermore, in the Vrasith study, 78.2% of the ICL was identified on the mesial surface of the implant restoration and other studies support finding a mesial bias of ICL [8,18,19]. In this present study, 13 of 13 sites where both ICL and DATFIR was observed were located mesial to the implant. Thus, evidence to date suggest a greater risk for ICL mesial to the implant restoration and this may explain the observed predominance of decay at mesial tooth in this study. The mechanism of ICL and decay risk is supported in a study between natural teeth where faulty contacts on PFM crowns were significantly associated with the presence of caries on adjacent teeth with the authors suggesting open contacts promote food impaction and may facilitate cariogenic bacteria and results in dental caries [20]. However, although food impaction adjacent at tooth surface is generally considered a predisposing factor for dental decay due to alteration of microbial flora, there remains a limited evidence for direct causation of food entrapment and decay, with the majority of evidence being observational or expert opinion, exemplified by the 1922 report of Basil and Bibby [21].

The implant abutment interface (IAI) and/or crown abutment interface offer a microgap environment where there are higher bacterial counts present. It is known that pathogenic bacteria are reported in the peri-implant tissues adjacent a microgap and so one potential mechanism is that high counts of bacteria in close proximity to a tooth could result in caries formation [9]. The microgap phenomenon can be further aggravated in instances where the margin of the implant crown has obvious discrepancy on radiograph.

In the present study, there were about 10% of sites where DATFIR was noted adjacent to an open margin on the implant crown. Indeed, proximity to an open margin relating to decay on adjacent sites has been reported in natural teeth adjacent to a PFM crown with an open margin [20].

The presence of “prior” restorations on teeth adjacent the implant was often noted in sites where DATFIR was observed. Thus DATFIR risk may be elevated by poor restorative margins in the adjacent restored tooth especially since such margin discrepancy is not uncommon, with one study reporting overhangs or marginal gaps at PFM crowns observed rate of 17.7% and 13.5% respectively [20]. Even if the “prior” restoration has intact margins, the type of material of the prior restoration can increase risk, as it has been shown that composite materials can lack buffering capacity, which may promote the shift to cariogenic bacteria [12]. Thus, a portion of DATFIR that develops may not be related to the presence of an implant alone per se but rather a combination of conditions, for example, if both ICL and prior restoration margin discrepancies are present. The presence of a prior restoration on the adjacent tooth and/or the presence of an open “margin” on the implant crown may be a factor in DATFIR, however in this report there is no control or comparison data so no conclusions can be drawn. Nonetheless, 45 of the 56 of DATFIR sites had one or more of the three parameters ICL, Prior restoration or Open margin.

Clinicians and patients may consider preventative strategies to manage this potential complication. Since it was observed that the DATFIR complication occurred most often at posterior teeth, mesial sites, ICL sites, and teeth with prior restorations, then when these conditions are present, clinicians could consider the use of proxy brush, fluoride and plan for closer supervision. Also since most cases of DATFIR were at posterior sites one may consider silver diamine in non-esthetic zones in a patient informed regarding root stain, as this is proven effective at reducing decay risk [22].

4.4. Limitations

One potential mechanism, which was not evaluated in this paper, is whether bone loss leading to root exposure of adjacent teeth following extraction or flap surgery for implant placement was a contributing mechanism for decay in relation to the presence of an implant [23,24].

Although this study reports 56 sites, from a potential of >13,000 implant placements, the paper did not calculate all proximal sites with adjacent teeth and did not record all sites where decay sites did or did not develop. This report was based on a convenience sample of cases noted at surgical office implant recall and some decay events could have been identified and managed at restorative office so not be accounted for in this study, as such this study does not provide any information on the frequency of DATFIR complication. Another limitation is this study did not account for extractions of teeth adjacent an implant site as the extraction may have occurred outside of the surgical office follow up for reasons unknown. The study did not systematically evaluate medical history, DMF scores, and oral hygiene scores, therefore no conclusion can be drawn from these potential risk parameters.

There were no controls or comparative site evaluations, so the effect of various parameters could not be evaluated for significance or relative risk, however some parameters identified in this report may warrant further investigation.

CONCLUSION

There is minimal information regarding the complication of decay adjacent to fixed implant restorations (DATFIR) in the literature. This paper presents a series of cases where decay on teeth adjacent to implants was observed and reports on possible trends in the occurrence of this complication. The DATFIR complication developed most often on posterior teeth after 3 to 5 years following implant placement and typically at the tooth mesial to the implant. The DATFIR complication also occurred most often in conjunction with other parameters, such as previously restored tooth, sites of ICL, and open margins on implant restoration. Some parameters did not appear to have an effect, such as age, sex, and mandible versus maxilla. A discussion between patient and clinician about this complication should be included as part of pre-operative informed consent and patients may also warrant more caries prevention strategies and closer follow up in certain cases.

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Received on 13-03-2018

Accepted on 22-03-2018

Published on 30-03-2018

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