Implant Fracture

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Implants fracture is a rare but possible complication that leads to implants failure after prostheses delivery. Fracture involves the forced separation of the implant neck into two or more parts. Mechanical properties play a key role in the failure of dental implant systems.

Keywords: implant fracture ; complications ; implant removal ; dental implants ; failure

1. Introduction

Since the discovery of osseointegration by prof. Peter-Ingvar Brånemark, implantology has undergone a considerable evolution allowing the successful treatment of partial and complete edentulism [1]. High implant survival and success rate could also be expected thanks to the improvement of surface treatments, implant and prosthetic materials, and geometry of implant body [2]. However, while the implant procedure is deemed to be safe, having dental implants installed is a surgical procedure. As for any surgical procedure, some risks may be involved. Even if the percentage of patients who end up having problems after receiving implant surgery is small, there are some patients that experienced several major complications, both biological and mechanical. Within these, progressive infections, lack of osseointegration, and implant fractures lead to implants failures [3][4].

Implant fracture is a possible, even if improbable, cause of implant failure, that occurs very rarely. Brånemark and co-workers, about forty-five years ago, firstly reported 0.8% of fractured implants [5]. Nevertheless, although implants were made on titanium grade one, mostly of the cases were complete arch restorations, that are less probable to fracture. Recently, according to a couple of review manuscripts, the prevalence of implant fracture was reported to be around 1.0–1.5% [6][7].

The use of a standard (from 3.75 mm to less than 5 mm) and wide (5.0 mm or more) diameter implants [8] is generally recommended in the posterior area to ensure sufficient contact between the bone and the implant, and at the same time, to allow sufficient occlusal load resistance. However, it should be emphasized that a minimum of 1.5 mm between the implant and the adjacent tooth, and 3 mm between implants, is essential to support the interdental papillae and to achieve adequate esthetics, reducing crestal bone loss [9]. Moreover, a minimum thickness of about 1.5 to 2.0 mm of bone must surround the entire implant surface, including the buccal and palatal/lingual sites, to reduce the risk of bone fenestration [9]. For the latter, thin ridges or limited space are a challenge that require advanced surgical techniques (edentulous ridge expansions, guided bone regeneration, etc.). With the aim to reduce the overall treatment time, costs, and patients' morbidity, narrow or extra-narrow diameter implants of ≥3.0 mm to ≤3.75 mm, or less than 3.0 mm, respectively, were used. Indeed, when the amount of horizontal available bone is less than 5 mm, the placement of mini (3.5 mm) or standard (4 mm) diameter implants without bone management procedures, can often lead to gingival recession, bone resorption, and in advanced cases, exposure and/or infection of the implants, with irreversible consequences for the implants survival and/or success rate [10]. Hence, the gold standard still remains horizontal guided bone regeneration.

Extra-narrow and narrow diameter implants are primarily indicated in the anterior area to replace mandibular incisors or maxillary lateral incisors. They are also indicated in case of reduced mesio-distal space, and/or thin vestibulo-lingual thickness [11], to allow implant placement in situations where there is not enough space for wider diameter implants. Thus, the need for bone augmentation procedures, or pre-prosthetic orthodontic tooth movement could be avoided. Nevertheless, narrow implants should be used in areas not subjected to high occlusal force, as indicated by the manufacturers. Hence, high risk of implant fracture may occur when extra-narrow and narrow implants are placed in premolar and molar area [12][13].

2. Incidence of Implants Fracture

Seven studies reported incidence of implant fracture [3][4][8][10][14][15][16]. Major of the studies reported an incidence of less than 1% [3][4][8][14][16]. Higher value was reported by Stoichkov and co-workers [15]. In this study, 5 implants fractured from a total of 218 (percentage 2.3%).

In a previous systematic review by Berglundh and co-workers in 2002 [3], evaluating 159 articles on complications in implantology, the incidence of implant fractures was less than 1% (0.08 to 0.74%), in a period of five years. Later, in two studies the incidence of implant fracture was 1.40% [10], and 0.23%, as reported by Sánchez-Pérez and co-workers in another literature review published on 2010 [14]. In a 2017 retrospective cohort study of Tabrizi and co-workers [4], 37 implants fractures were experienced out of a total of 18,700 implant (0.2%). In the same year, another retrospective study by Chrcanovic and co-workers [8], reported an incidence of 0.44%. Overall, the fractured implants were 44 out of 10,099 in a total of 2670 patients. A year later, Stoichkov and Kirov reported an incidence of dental implant fracture of 2.3% experienced in 101 patients with 218 dental implants followed for a period ranging between three to 10 years [15]. More recently, Implant fracture failure rate of 0.92% was reported by Dong-Woon Lee in a retrospective study published into 2019, on 5124 patients and with up to 12-year of follow-up [16]. Overall, the percentage of fractured implants was 0.52% (302 implants out of 57,646, **Table 1**).

Table 1. Percentage of implant fracture.

Study	Fractured Implants	Total Implants	Percentage
Berglundh et al. [3]	**19**	**7279**	**0.26%**
Tabrizi et al. [4]	**37**	**18,700**	**0.2%**
Chrcanovic et al. [8]	**44**	**10,099**	**0.44%**
Gargallo-Albiol et al. [10]	**21**	**1500**	**1.40%**
Sánchez-Pérez et al. [14]	**2**	**844**	**0.23%**
Stoichkov et al. [15]	**5**	**218**	**2.3%**
Lee et al. [16]	**174**	**19,006**	**0.92%**
Grand total	**302**	**57,646**	**0.52%**

3. Risk Factors for Implants Fracture

Seven studies reported incidence of implants fracture [3][4][7][8][10][15][16]. According to Berglundh and co-workers [3], poor implant planning, implant-abutment misfit, and overloading were the most common reasons for implants fracture. Later, Tabrizi and co-workers reported as possible causes of implants fracture long lasting time, treated area, implant and prosthetic design [4]. For all of these variables, a statistically significant correlation was found. Risk of implant fracture was 0.38/1000 and 1.46/1000 at the 1- and 5-year follow-up, respectively. Moreover, implant fractures occurred more often in the premolar and molar area (94.6%). Finally, the incidence of implants fracture was higher for conical connection implants and for single screw-retained prostheses.

In agreement with these results, a larger retrospective evaluation by Chrcanovic and co-workers [8], reported a mean time before implant fracture of 95.1 ± 58.5 months, with half of the fractures occurred between two and eight years. The authors also identified five more possible influencing factors: high grade titanium (72.9% reduced risk); bruxism (1819.5% increased risk); adjacent to a cantilever (247.6% increased risk); implant length (22.3% increased risk per mm); and implant diameter (96.9% less risk per mm). In this retrospective study there was no statistically significant differences between prosthesis design. The chi-square statistic is 2.782. The p-value is 0.594943. The result is not significant at $p < 0.05$. Data are reported in the **Table 2**.

Table 2. Percentage of implant fracture according to the prosthetic design (by Chrcanovic et al. [8], modified).

Prosthetic Design	Fractured Implants	Total Implants	Percentage
Single crown	**6**	**1683**	**0.36%**
Partial-fixed (2 to 6 units)	**12**	**2600**	**0.46%**

Prosthetic Design	Fractured Implants	Total Implants	Percentage
Partial-fixed (7 to 10 units)	**1**	**371**	**0.27%**
Full-arch fixed	**23**	**5055**	**0.45%**
Overdenture	**2**	**293**	**0.68%**
Grand total	**44**	**10,002**	**0.44%**

Higher incidence of implant fractures was established in the area of the molars and premolars. Based on the study by Gargallo-Albiol and co-workers [10], the onset of these complications occurs during the first two to three years after the functional load of the implants. Also in the study of Chrcanovic and co-workers [8], statistically significant difference was found for implant diameter. The chi-square statistic is 2.782. The *p*-value is <0.0001. The result is significant at $p < 0.05$. Data are reported in the **Table 3**.

Table 3. Percentage of implant fracture according to the implant diameter (by Chrcanovic et al. [8], modified).

Prosthetic Design	Fractured Implants	Total Implants	Percentage
Narrow (3.00–3.50 mm)	**14**	**1038**	**1.35%**
Regular (3.70–4.10 mm)	**30**	**8873**	**0.34%**
Wide (4.20–5.00 mm)	**0**	**186**	**0%**
Grand total	**44**	**10,097**	**0.44%**

In agreement with previous reports, Stoichkov and Kirov reported as most common causes associated with implant fracture, the implant design (e.g., diameter and length, biomaterial, and macro-design of the implant), physiologic or biomechanical occlusal overload, and incorrect operative and prosthetic planning [15].

In the retrospective study by Dong-Woon Lee [16], the implant diameter, location, history of bone graft, and microthread presence were significantly correlated with implant fractures. On the contrary, wide-diameter implants had a reduced fracture risk within 90 months, after which the diameter did not correlate with fractures. Implants placed in the anterior mandible had a lower fracture risk within 90 months; mandibular premolar implants corresponded with a lower risk up to 90 months on function. Implants without a history of bone graft or without microthreads were more likely to fracture throughout the follow-up time.

In two retrospective studies the percentage of implants fracture, for different implant companies and systems were reported [8][16]. Even if a direct comparison is not possible, all of the major implant brands fractured with percentage from 0.74% (Osstem TSIII with conical connection) to 2.57% (Nobel replace with butt internal connection) [8][16].

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