Early Implant Failure Using Guided vs. Non-Guided surgical protocol: A Review of Electronic Health Records in a School of Dental Medicine

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Ali Ashkanani, DDS.

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This thesis was presented

by

Ali Ashkanani

It was defended on

June 7, 2023

and approved by

Thomas Kunkel, DMD, Residency Program Director, Assistant Professor, Department of Prosthodontics

Warren Stoffer DMD, Assistant Professor, Department of Graduate Prosthodontics Nilesh Shah, PhD, Assistant Professor, Department of Biostatistics

Thesis Advisor: Atousa Azarbal, DMD, MDS, Assistant Professor, Department of Prosthodontics

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Objectives: The aim of this study was to compare the early failure rates of guided and non-guided implant surgery, as well as implant placement site and implant system used.

Methods: A one-year retrospective evaluation of electronic health records (EHRs) was conducted at the University of Pittsburgh, School of Dental Medicine (SDM). Implants placed from February 28th, 2022 to March 1st, 2023 were recorded. Whether they were guided or unguided, all failure implants within the same time frame were evaluated. The placement site and implant systems used were documented.

Results: 456 implants were placed. Only 20 implants failed, representing a 4.2% failure rate. 220 implants were placed in the mandible. 236 implants were placed in the maxilla. There was no statistically significant difference in the early failure rate between the maxilla and the mandible ($p>0.05$). In terms of early implant failure, there was no statistical difference between the guided and non-guided surgical protocols ($p>0.05$). NobelActive (Nobel Biocare) demonstrated a failure rate of 16.42%, which was statistically significant ($p<0.05$) when compared to other implant systems.

C**onclusion:** Within the limitations of this study, there was no difference between guided and non-guided surgical protocols in terms of early implant failure. Maxillary or mandibular implant placement had no effect on early implant failure. The implant systems used had statistically significant failure rate differences, but the correlation was unclear. Therefore, future

studies should investigate further systemic and local factors that may be associated with early implant failure to provide stronger evidence.

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Preface

I would like to begin by thanking my wife for her unwavering support throughout my residency. Second, I'd like to express my appreciation to the faculty at the University of Pittsburgh for their guidance. Dr. Atousa Azarbal, my major advisor, and Drs. Warren Stoffer, Thomas Kunkel, and Nilesh Shah, my committee members, deserve special recognition. I would also like to appreciate Mrs. Christine Zielmansky from the multidisciplinary implant center for providing us with the necessary research data.

1.0 Introduction

Despite evidence showing dental implants have a survival rate of more than 90%, it is important to comprehend the potential risk factors for dental implant failure (Buser et al., 2012). The literature defines implant failure as the clinical condition that mandates the removal of the implant. Implant failure is determined by the presence of signs and symptoms that necessitate its removal. Failure of an implant is equivalent to its loss (Chrcanovic et al.). Early implant failure is defined as an implant exhibiting clinical movement prior to the insertion of the final prosthesis or peri-implant radiolucency on the initial radiograph performed within a few weeks of final loading with the definitive restoration (Kang DY). While failures after loading are typically the result of peri-implant disease caused by a variety of biological causes or mechanical overload (Salvi 2018). The effective integration of a dental implant is contingent upon obtaining primary mechanical stability to mineralized bone. Preserving the vitality of bone cells is essential for the healing of bone, as well as for building a stable bone-to-implant contact. Nonetheless, bone tissues are susceptible to heat injury. Exposure of bone tissue to an absolute temperature of 47 °C for one minute causes irreversible damage to the bone (Eriksson & Albrektsen, 1983). With the advent of digital dentistry, guided implant placement has become increasingly prevalent. Using a digital scan of the dental arch and a cone beam computed tomography (CBCT) of the jaws' bone to plan the placement of the dental implant in the bone, a surgical guide is fabricated in accordance with the principle (Adams et al). Guided implant placement with drill guides has been recommended above the traditional technique due to significant enhancements in prosthetically driven implant placement, accuracy, time efficiency, and reduction in surgical error (Ganz et al, 2005). It is demonstrated that guided implant procedures provide more implant precision and accuracy than

conventional surgery (Schneider et al.). Yet, there is considerable risk that heat-induced bone necrosis may develop during guided implant placement because the surgical guide may prevent irrigating saline from entering the drilling site. In addition, friction between the drill and the guide metal sleeve may contribute to temperature increases (Markovic et al.).

Implant failure is a multifactorial biomechanical process. Systemic variables, such as diabetes, radiation, smoking, periodontitis, and other oral and medical disorders, might contribute to implant failure. Implant location has an impact on implant failure. Implants placed in the mandible tend to have higher survival rates than those placed in the maxilla (Alsaadi et. al.). However, there are multiple studies that show no significant difference in implant failure based on the placement location (Dvorak et. al). Bone quality (I-IV) is a potential risk factor of implant failure. Statistically, sites with inferior bone quality and a lack of bone volume may influence implant failure rates (Chrcanovic et al.).

Failure of dental implants can be associated with surgical techniques. In many cases, the bone quality, quantity, or both are inadequate for dental implant insertion. In certain cases, teeth are extracted and implants are immediately inserted at the extraction site, with or without bone grafting. In some cases, the extraction socket is retained with bone graft material and revisited for implant insertion following recovery. Lack of bone amount necessitates guided bone regeneration (GBR) prior to implant placement in numerous clinical circumstances including edentulous locations (Margonar et al.). The aim of this research is to answer the following question: “Is there a difference in the early failure rate between guided and non-guided dental implant placement?” In addition, it is of interest to discover a potential correlation between early implant failure and the site of implant (maxillary or mandibular arch) and the dental implant system used. Through a retrospective analysis of the electronic health records (EHRs) of patients who were treated at the

University of Pittsburgh, School of Dental Medicine (SDM) for dental implants over the course of one-year, the purpose of this study is to compare between the early failure rate of guided and non-guided implant surgery in addition to the site of implant placement and the implant system used. The null hypothesis is that there is no association between early implant failure and the surgical protocol (guided vs. non-guided), implant site (maxilla vs. mandible), and implant system used.

2.0 Specific Aims

Aim 1: To determine the correlation between early implant failure and the use of guided vs. non-guided surgery.

Aim 2: To evaluate the association between early implant failure and the site of dental implant (mandible vs. maxilla).

Aim 3: To determine the relationship between early implant failure and the utilized implant systems.

3.0 Material and Methods

The Institutional Review Board of the University of Pittsburgh, School of Dental Medicine approved the study's design and methodology (IRB STUDY22040069). Due to the fact that the study was a retrospective analysis of existing electronic health records (EHRs), written informed consent was waived. An electronic health record (EHR) search was performed (aXium, Henry Schein Inc., Melville, NY, USA) of patients that received dental implants at the multi-disciplinary implant center of the University of Pittsburgh, School of Dental Medicine between February 28th, 2022 and March 1st, 2023. The author adopted a narrow definition of early implant failure as an endosseous dental implant surgically placed during the one-year period that was actively removed within the same time frame due to loss of osseointegration prior to the loading of the restoration. The patient population was divided into two groups: the survival cohort and the failure cohort. The failure cohort was defined as any patient who received a dental implant and experienced failure before the restoration process within the time frame of the study. This was statistically compared to all patients who received dental implants during the same time period (survival cohort). Implants that were removed within the prescribed time frame but had been placed before the study's time frame were excluded. Similarly, dental implants that were removed at the multi-disciplinary implant center that were originally placed outside the School of Dental Medicine (SDM) were excluded from the failure group.

The American Dental Association (ADA) code (D6010, surgical placement of endosteal implant) was used to search for all the implants placed during the previously mentioned time period. The ADA codes for implant removal (D6100, D6100X, and D6100Y) based on the complexity of the removal procedures were searched to document all the implants that required

removal during the same time period. The ADA code for Radiographic/surgical implant index (D6190) was used to determine whether a surgical guide was utilized during the procedure. The surgical guides used in all procedures were designed with 3Shape Trios (3Shape, Denmark) and printed in house with 3D additive technology (Fig. 1, 2, and 3). Subsequently, the author reviewed the complete (EHRs) and progressive notes of every patient who had been identified through this process. A failure was unequivocally identified after confirming the presence of a progress note that expressly mentioned implant removal. In cases where a patient's implant avulsed outside the clinic and they returned to the clinic with a failed implant outside the mouth, the failure was identified by reviewing the progress note. The author searched the utilization of a surgical guide for each implant procedure. In addition, the placement site, maxillary and mandibular arches, and implant systems were documented.

Four different implant systems were studied; Straumann BL SLActive Roxolid, NobelActive (NobelBiocare), NobelReplace Conical Connection (NobelBiocare), and NobelParallel Conical Connection (NobelBiocare).

The collected data were input into Microsoft Excel spreadsheets. Subsequent analyses of failure rate in regards to the use of guided surgery, implant site, and implant system was performed using a Chi-square test. A p-value of < 0.05 was considered statistically significant.

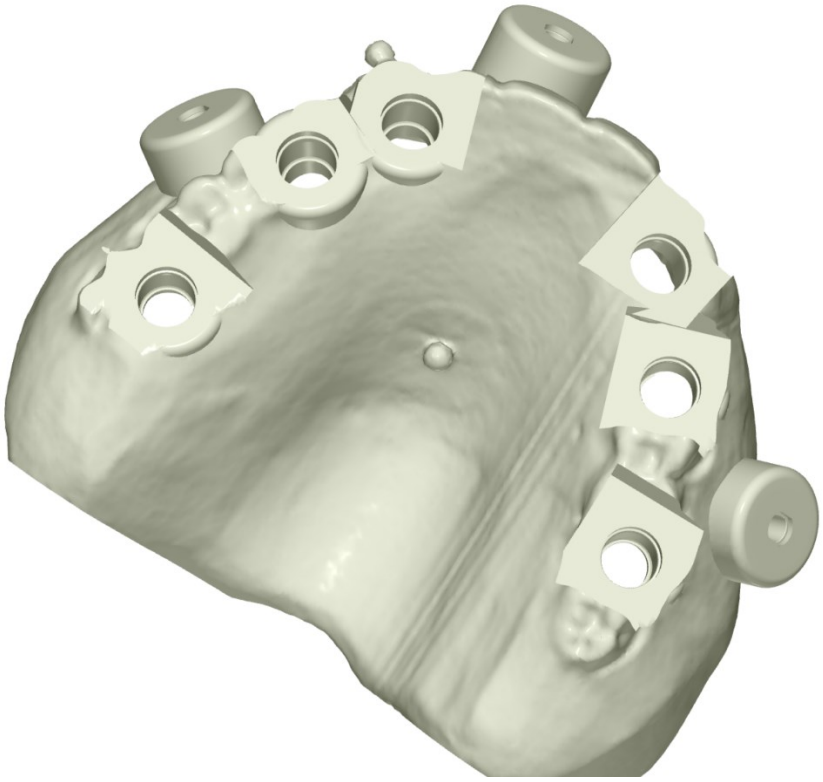

Figure 1. Maxilla mucosa supported surgical guide.

Figure 2. Mandibular mucosa supported surgical guide.

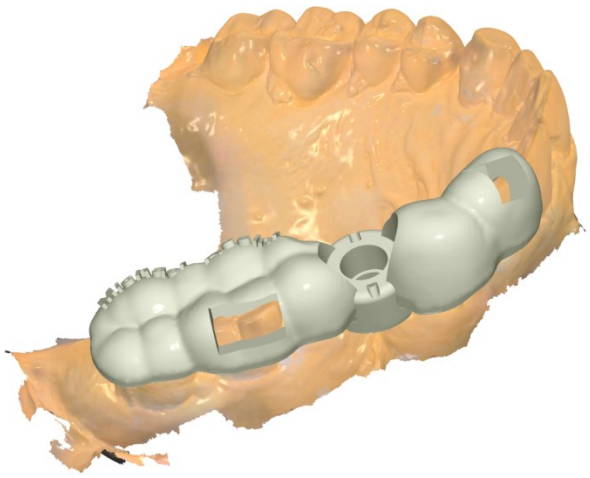

Figure 3. Tooth supported surgical guide.

4.0 Results

A total of 456 implants were placed in the time between February 28th, 2022 and March 1st, 2023. 236 implants were placed in the maxillary arch, and 220 implants were placed in the mandibular arch. Total number of failed implants is 20, with an early failure rate of 4.2%. In the mandible, 13 implants failed with a failure rate of 5.6%. 7 implants failed in the maxilla with a failure rate of 2.9%. The difference in failure between the maxillary and mandibular arches was not statistically significant ($p=0.142$). In regards to the site of implant, the null hypothesis was accepted (Table 1).

290 implants were placed non-guided. 166 implants were placed following the guided surgery protocol. The failure rate for guided is 4.1%. The failure rate for non-guided is 4.3%. We used a chi-square test and determined that this difference was not statistically significant ($p=0.898$). The null hypothesis was accepted (Table 2).

Regarding the implant system used, the failure rate for Nobel Active is 16.42%. The failure rate for Nobel Parallel is 1.79%. The failure rate for Nobel Replace is 4.23%. The failure rate for Straumann is 1.77%. We used a Fisher's exact test to determine that there is a statistically significant difference in failure rate by type ($p<0.001$). The null hypothesis was rejected as there is a difference in the failure rate based on the dental implant system used (Table 3).

Table 1. Failure rate based on site of placement (maxilla vs. mandible).

Fail	*Mandible*	*Maxilla*	*Total*
0	220	236	456
	48.25	51.75	100.00
	94.42	97.12	95.80
1	13	7	20
	65.00	35.00	100
	5.58	2.88	4.20
Total	233	243	476
	48.95	51.05	100.00
	100.00	100.00	100.00

Pearson chi2 (1) = 2.1523 Pr = 0.142

Table 2. Failure rate based on surgical protocol (guided vs. non-guided).

Fail	*Non-guided*	*Guided*	*Total*
0	290	166	456
	63.60	36.40	100.00
	95.71	95.95	95.80
1	13	7	20
	65.00	35.00	100
	4.29	4.05	4.20
Total	303	173	476
	63.66	36.34	100.00
	100.00	100.00	100.00

Pearson chi2 (1) = 0.0163 Pr = 0.898

Table 3. Failure rate based on dental implant system.

Fail	*NobelActive*	*NobelParallel*	*NobelReplace*	*Straumann BL*	*Total*
0	56	55	68	277	456
	64.2	53.6	68.0	270.2	456.0
	12.28	12.06	14.91	60.75	100.00
	83.58	98.21	95.77	98.23	95.80
1	11	1	3	5	20
	2.8	2.4	3.0	11.8	20.0
	55.00	5.00	15.00	25.00	100.00
	16.42	1.79	4.23	1.77	4.20
Total	67	56	71	282	476
	67.0	56.0	71.0	282.0	476.0
	14.08	11.76	14.92	59.24	100.00
	100.00	100.00	100.00	100.00	100.00

Pearson chi2(3) = 29.7854 Pr = 0.000
Fisher's exact = 0.000

5.0 Discussion

This retrospective study examined the relationship between early implant failure and the use of a guided versus non-guided surgical protocol, the location of implant, and the implant system employed. All implants were placed by post-graduate residents under the supervision of attending school faculties, an oral and maxillofacial surgeon, a periodontist, and a prosthodontist. Implants were placed following the manufacturer's recommendations. The overall early failure rate in the current study was found to be 4.2% at the implant level. This rate falls within the reported range of (1.3%–6.36%) that was reported by Kang DY et al. In a retrospective study conducted by Chranovic et al, several anatomical, patient, health, implant-related factors were collected from 2,670 patients who received 10,096 dental implants, to determine the potential local and systemic risk factors of implant failure. The definition of early failure in their study was the removal of the implant up to the abutment connection. Among the 10,096 implants inserted, 176 implants failed (early failure) in 139 patients. The early implant failure rate in that study was 1.74% at the implant level. (Chrcanovic et al). The failure rate in Kang DY's retrospective study, which was conducted in a dental institution, was 4.4%, which is slightly higher than the early implant failure rate of 4.2% reported in this present study.

With the introduction of digital dentistry, guided implant surgery has become more common. Due to significant improvements in prosthetically driven implant placement, accuracy, time efficiency, and reduction of surgical error, guided implant placement with drill guides has been recommended over the traditional technique (Adams et al.). Nonetheless, there is a substantial risk of developing heat-induced bone necrosis during guided implant placement, as the surgical guide may prevent irrigating saline from accessing the drilling site (Alhroob et al.). In addition,

mechanical friction between the drill and the metal guide sleeve may contribute to an increase in temperature. Numerous potentially harmful aspects have been observed in early failure of dental implants, including excessive torque value beyond the manufacturer's recommendation during implant insertion, chronic inflammation, residual granulation tissue and heat buildup due to lack of cooling (Alhroob et al.). Significantly, a rise in intraosseous temperature to 47°C over 1 minute is commonly regarded as the threshold for bone necrosis (Waltenberger et al). According to the findings of the present investigation, there was no difference in the failure rate between guided and non-guided surgery. Most studies that measure the heat generated during implant placements are conducted in vitro (waltenberger et al., Alhroob et al., Frösch et al.). It is understood that the in vitro investigation does not precisely replicate the oral environment. The studies that compare the heat generation of guided versus non-guided surgery reveal an increase in heat generation with guided surgery; however, this increase mostly did not surpass the threshold temperature of bone necrosis of 47°C over 1 minute reported by Erikson. Frösch et al conducted an in vitro study aimed to assess the heat generated during guided implant placement vs a free-handed conventional technique for a single and sequential drilling regimen. Single drilling entails proceeding directly to the final drill, whereas sequential drilling employs progressively smaller drills until the final larger diameter drill is reached. The rotational speeds were determined based on the manufacturer's suggestions. Using an infrared camera, temperature measurements were taken during normal osteotomy preparations in polyurethane foam blocks acting as artificial bone. Study samples were divided into four groups; single drilling protocol with a surgical guide, single drilling protocol without a surgical guide, sequential drilling protocol with a surgical guide, and sequential drilling protocol without a surgical guide. 25°C-temperature distilled water was used for irrigation. Guided and conventional drilling, in addition to single and sequential drilling, were compared using a one

way ANOVA with Tukey's post hoc test. = 0.05 was chosen as the threshold for statistical significance. Guided osteotomy preparation yielded significantly higher temperatures than the non-guided protocol for the 2.2 mm, 3.5 mm, and 4.2 mm drills ($p = 0.032$, $p = 0.005$, and p 0.001, respectively). The reason for this was that the surgical guide prevented irrigation fluids from entering the drilling sites. Sequential drilling resulted in more heat production and a longer duration of latent heat than a single drilling operation. Except for the sequential guided drilling protocol with the 4.2 mm. drill, the length of heat exposure over the critical temperature was less than 1 minute for all drilling procedures. The author explained that sequential drilling generates more heat because small drills have smaller flutes than larger drills, which reduces the transit of bone out of the cavity, resulting in higher friction and temperature development. The successive larger-diameter drills will then begin in bone that has already been warmed, causing a rise in temperature. The author also suggested that an intermittent drilling process coupled with a constant pumping motion of the drill could have a positive impact on the transfer of bone particles and cooling irrigation. This study concluded that guided drilling necessitates careful consideration of the emergence of heat. It is essential to note that this research was conducted on artificial bone blocks with a homogenous consistency and no blood flow or body temperature, which are not identical to living bone. This is the only study to report the generation of heat during guided surgery that exceeded the bone necrosis threshold temperature for more than one minute when the 4.2 mm drill was used with sequential drilling. The rest of the drills did not surpass the temperature threshold of bone necrosis. In contrast, the other in vitro studies observed a rise in temperature that was clinically insignificant as the temperature rise was below 47°C (Waltenberger et al., Markovic et al., and Alhroob et al.). The suggested technique by Frösch et al. to use an appropriate intermittent drilling procedure to allow constant access for irrigation fluid in order to avoid the

clogging effect of bone fragments on the cutting edge and drill flutes may have a high clinical value.

Another in vitro study done Markovic et al aimed to evaluate the effect of surgical drill guide and saline temperature used for irrigation on thermal changes of the local bone during implant site drilling, as well as the effect of saline temperature on surgical drill guide temperature. 48 bovine rib specimens were randomly assigned to four experimental conditions: Drilling protocol (guided or non-guided) and saline (at 25°C or 5°C). As a method for measuring temperature, infrared thermography in real time was used. The primary outcome was the change in bone temperature assessed at three osteotomy depths during implant site drilling, while the secondary objective was the change in drill guide temperature. The influence of drill guide on variations in bone temperature was significant at the osteotomy entrance, while the effect of saline temperature was significant at all osteotomy levels (p 0.001). Guided surgery and saline irrigation at 25°C were related to the greatest increase in bone temperature. The increase in temperature of the drill guide was substantially greater when 25°C saline was utilized (p 0.001). The author concluded that guided implant site preparation creates higher local bone temperatures than conventional drilling, although these temperatures do not surpass the threshold for thermal bone necrosis. They added that although saline at ambient temperature controls heat sufficiently during drilling, chilled saline is more effective, regardless of the use of a surgical drill guide. Regardless of the finding of our present study that there is no difference in failure between guided and non-guided surgical protocol, the use of pre-cooled saline may prevent excessive heat generation. Another study recommended the use of a surgical guide with a cooling channel which can reduce the generated heat by 1.9 folds (Liu et al.). The guides that were used in the present study had no cooling channels in their designs. The result of in vitro study done by Markovic et al. is consistent

with the result of the present retrospective study that the heat generation with guided surgery is not to a clinical significance, hence no difference in failure rate between guided and unguided surgery was noted.

Another study by Alhroob et al. the authors examined in vitro heat generation between guided and non-guided implant insertion. This comparative laboratory investigation involved drilling osteotomies of varying lengths in artificial bone blocks using either the standard approach or a surgical guide. Using a Thermocouple Type K at a point drilled 1 mm distant from the osteotomy, temperatures between the two groups were observed. There were significant changes in heat generation between the conventional group (41.07°C) and the surgical guide group (42.97°C). Additionally, longer osteotomies were associated with increased heat production. The authors suggested including cooling channels into the surgical guide's design to prevent an increase in bone temperature. Particularly when drilling is performed on high density bone types 1 or 2 defined by Lekholm and Zarb. Despite the fact that the temperature in the guided surgery group was significantly higher than in the control group, the authors decided that the peak temperature was well below the bone necrosis threshold. This study is consistent with the result of our study that there is no difference in failure rate between the guided and non-guided surgical protocol.

In a study conducted by Boa et al. the investigators evaluated the rise in temperature between guided and non-guided surgery performed on bovine rips at irrigation fluid temperatures of 10°C, 15°C, and 20°C. It was discovered that guided drilling with 10 °C irrigation produced a substantially smaller temperature increase than guided drilling with 20 °C irrigation. The study suggests using irrigation fluid that has been pre-cooled to 10 °C since it reduces the difference between guided and freehand drilling. Although there was no difference between guided and non-guided surgery in our study, it may be clinically advantageous to use pre-cooled saline to ensure

that heat generation is maintained below the threshold of bone necrosis. Another study found that the use of a 4°C saline irrigation may result in improved, faster recovery (Turkyilmaz et al.).

Misir et al. measured the heat generation after implant placement in a bovine femoral cortical bone model with and without the use of surgical drill guides in an in vitro study. Internal, external, and both irrigation systems were utilized for the guided protocol. The temperature was measured using a K-type thermocouple at a distance of 1 mm from the osteotomy at depths of 3, 6, and 9 mm. The temperature readings at 3, 6, and 9 mm depth with the surgical guide were 34,2 degrees, 39.7 degrees, and 39.8 degrees Celsius, whereas without the surgical guide, the values were 28.8 degrees, 30.7 degrees, and 31.1 degrees Celsius. The authors concluded that the use of a surgical guide produces significantly more heat than conventional implant placement, regardless of the form of irrigation. Although a significant difference in temperature was observed in that study, it remains below the bone necrosis temperature. This in vitro study yielded a statistically significant result, but its clinical relevance may be limited as the highest temperature generated with the guided protocol was well below the bone necrosis threshold temperature. Moreover, Dos Santos et al. found that the guided drilling protocol heat generation did not exceed critical bone necrosis temperature when implants were placed in rabbits' tibias. In our present study, we did not observe a statistically significant difference in early implant failure between the guided and non-guided surgical protocols, indicating that the heat generated by the use of a surgical guide may not be clinically significant.

Vercruyssen et al. placed 314 implants in 59 patients as part of a randomized controlled trial. The patient population was randomly divided into two surgical protocol groups: guided and conventional. Clinical and radiographic evaluations were performed on the day of implant placement, restoration loading, and the one-year follow-up appointment. There was no implant

loss reported. The authors concluded that there was no difference in implant and patient outcome variables between guided and conventional implant treatment after one year of follow-up. At the time of implant loading, two patients in the guided surgery group presented implants with acute abscess formation and suppuration. The author reported that this may be an indication of suppurative osteomyelitis caused by bone heating during implant osteotomy preparation. In a clinical context, it is impossible to measure the heat generated during osteotomy, so the authors were unable to ascertain the temperature difference between the two groups. Therefore, it was challenging to link the implant failure to the possibility of excessive heat generated by the use of a surgical guide.

The association between implant location and failure remains a topic of discussion. Regarding implant placement sites, the present study reveals that the incidence of early implant failure was marginally higher in the mandibular arch than in the maxillary arch, but this difference was not statistically significant ($p>0.05$). In contrast to our findings, Alsaadi et al reported that implants placed in the maxilla had significantly higher rates of failure compared to implants placed in the mandible. In the same study they found no correlation between smoking, systemic health factors (hypertension, diabetes, osteoporosis, Crohn's disease) and implant failure. On the other hand, a retrospective study that evaluated 283 immediately loaded implants in 25 patients over 120 months found no significant difference in the failure rate based on the site of implant which is consistent with the results of the present study except for the fact that they evaluated late implant failure. It was concluded that neither the implant site nor the time of implantation were associated with unsuccessful outcomes (Strietzel et al). Comparing anterior versus posterior implant location, Alsaadi showed that implants placed in a posterior locations are more susceptible to failure compared to those placed in an anterior location. In our present study, we did not compare implants

placed in anterior versus posterior regions of the arch. Noda et al. in a longitudinal retrospective study found that maxillary implants and posterior implants had statistically significant higher rates of late failure. Else ways, the rate of implant failure in posterior regions was not significantly different than anterior regions. The impact of the implant site on failure remains unclear and requires further investigation. Chrcanovic et al. found that the quantity and quality of the bone at the implant site was not likely a determinant of early implant failure in the patients based on the Lekholm and Zarb (1985) classification. Regarding the quality of bone, Alsaadi et al. reported that bone grade 4 was associated with significantly more late failures than bone grade 2, whereas a lack of bone volume did not significantly affect the late-failure rate. In contrast, in our present study we found that the early failure rate in the mandible (type I and II) bone was higher than the maxilla (type III and IV) bone. Kang DY, et al. evaluated several potential risk factors that may increase the risk of early implant failure, including gender, age, surgeon experience, implant diameter and length, placement site, and type of bone graft. After conducting a multivariate regression analysis, they determined that only the placement site and surgeon's experience were statistically significant variables and implant placement sites were not significant contributing factors in failure. Similar to our findings, they reported that more implants failed in the mandible than in the maxillary arch, but theirs was statistically significant.

In regards to the correlation between early implant failure and the implant system used; the present study found the NobelActive NobelBiocare (Gothenburg, Sweden) had a significantly higher failure rate of 16.42% in comparison to the other implant systems used ($p<0.001$). In a retrospective study conducted in a private clinic by Jemt et al. on 1017 patients, 3082 implants were placed and monitored for a mean follow-up period of 11 years. The authors found a correlation (Hazard Ratio = 2.48) between late implant failure and the use of NobelActive Conical

Connection NobelBiocare when compared with other implant systems used. Their results were in consistency with the results of our study. In the same review, a correlation between late implant failure and smoking was observed with an HR of 2.11. The high failure rate associated with the use of NobelActive was attributed to the increased use of this implant system in more complex surgical cases e.g. in the upper jaw with poor quality bone, direct/immediate operations with bone graft, patients with history of periodontitis, and one-stage procedures. In addition, the use of NobelActive CC implants increased during grafting procedures. Thus, the high failure rate of NobelActive was linked to the use of this implant system in those complex clinical conditions. In a systematic review, Do TA et al. found no correlation between implant system and late failure. This systematic review did not assess early implant failure in relation to the implant brand. In our study, the complexity of the implant site was not evaluated, regardless of whether it was a grafted site, implant that was immediately placed and grafted, or implant placed with simultaneous sinus augmentation. Thus, we are unable to determine if NobelActive was predominantly utilized in intricate clinical scenarios. This study demonstrates that Straumann BL SLActive implants were utilized the most (n=277), but their failure rate was the lowest compared to other implant systems (1.77%). There was no statistically significant difference between the other implant systems used. Another potential risk factor that can be contributing to the early failure is compression necrosis. Dental implants with aggressive microthreading tend to have high initial torque values in D1 and D2 dense quality bone based on Misch classification (Misch). The high torque value in dense cortical bone can result in compression of bone beyond its physiological limit may result in ischemia, necrosis, or sequestration. According to the orthopedic literature, when bone strain exceeds a certain threshold level, irreversible damage occurs in the form of microcracks and plastic deformation, resulting in implant retraction or failure (Haider et al). In a case report from the

graduate periodontics department at the University of Michigan, four implants had to be removed one month after implantation due to extensive bone loss in a 47-year-old female with no systemic disease that could compromise healing (Bashutski et al). The author concluded that the early loss of the four implants could be linked to compression necrosis as the implants were placed in D2 cortical bone and no implants pre tapping was performed which could increase the pressure in the implant bed beyond the physiologic threshold. The initial torque values of the placed implants were not recorded by the authors. It was recommended in the same case report to follow manufacturer's recommendations of the insertion torque values and not to exceed the maximum torque level. Additionally, reversing the implant by a quarter turn after insertion may reduce tension on the adjacent bone, particularly when tapered implants are utilized. Pretapping is necessary when inserting implants into dense bone, and it may eliminate the need for high torque values. On the contrary, in a prospective study involving 42 participants, 66 implants were inserted. The purpose of the study was to determine the effect of maximal insertion torque on implant survival. The MIT of nine implants ranged between 30 and 50 NCM. The MIT of the 42 implants in the experimental group exceeded 70 NCM, with a mean of 110,6 NCM. Utilizing an electronic torque measuring device, the insertion torque of the implant was determined. One year later, there was no difference in bone loss between the two groups. The author concluded that high insertion torques did not inhibit osseointegration. At the time of loading and a year later, the marginal bone levels of the control and experimental groups were similar (Khayat et al). In the present study, it was impossible to record the torque value of each implant because the progress notes typically stated that the torque value exceeded 35 NCM without specifying the precise value. Most of the NobelActive implant that failed were placed in the mandible (n=6) which has high

density bone Type I and II (Lekholm and Zarb) classification. Therefore, compressive necrosis may be a contributing factor, but a definitive link cannot be established.

6.0 Limitations of the Study

This present study had some limitations. We did not examine the systemic factors, such as diabetes, smoking, osteoporosis, radiation exposure history, medications, etc., which may contribute to implant failure. Other potential local risk factors, such as periodontitis, graft sites, implants installed promptly, etc., were not addressed in the study. Implant failure is a multifactorial biological process associated with a number of risk factors.

7.0 Conclusion

Within the limitation of this study, we can conclude that there is no difference in the rate of early implant failure between guided and non-guided surgical approaches. The generation of heat caused by the use of a surgical guide may not be clinically significant. In terms of early failure, there is no difference between implants placed in the maxilla or the mandible. The NobelActive system was substantially associated with a higher rate of early failure, but this correlation could not be interpreted. Therefore, systemic and local factors that may be associated with early implant failure should be investigated further in future studies to provide stronger evidence.

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