Peri-Implant Bone Stability and Patient Satisfaction with Mandibular Overdenture Retained by 3 One-Piece Implants in an Undergraduate Clinic Setting.

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Increased patient satisfaction with improved retention and stability of implant supported complete mandibular dentures has been consistently identified through multiple studies and using variety of implant systems. This particular study focused on I. Evaluating patient satisfaction with an implant retained mandibular overdenture, II. Evaluating the efficacy of using a One-Piece implant in an undergraduate clinic, III. Assessing peri-implant bone loss and compare it to accepted clinical standards. The study evaluated patient's perception of their mandibular denture functionality through a use of satisfaction survey and radiographic evaluation of peri-implant bone levels. Multiple variables are to be considered when it comes to determining the overall success of an implant-retained overdenture. Our goal was to evaluate the improvements in stability and retention of a complete mandibular denture, while reducing those variables. Placing 3 one-piece implants at predetermined positions in patients' lower jaws and securing the denture in with GPS attachments, minimized the amount of variables and allowed to draw a more reliable conclusion. The results of this study with regards to patient satisfaction with implant retained overdenture as well as peri-implant bone stability were consistent with previous research in this area. In addition, statistical analysis performed has confirmed two variables as being significantly different as related to bone loss. During the first year there was more bone loss observed, than during the following year (P=6.82E-7). The evaluation of the two different collar heights showed that the 1.5mm collar implants were associated with greater instances of bone loss in first year post placement (P=7.71E-6). Based on the findings the study suggests that when performed in an undergraduate clinic setting, a mandibular overdenture, retained by a 3 one-piece implants with 3mm collars, can provide a patient with an

improved satisfaction with their lower denture without additional compromise to osseous structure while maintaining lower cost to the patient.

Introduction:

Stability and retention of complete removable dentures and the ability to improve patients' satisfaction and quality of life have been a goal in dentistry.[i] [ii] Continuous resorption of the edentulous alveolar ridges leads to reduced areas of support, stability, and retention, making fabrication and maintenance of a well-fitted and stable complete denture a challenge.[iii] A comparison of complete denture wearers with severely resorbed mandibles before and after mandibular implant overdentures found significant improvement in function with overdentures. [iv] However, there are multiple additional factors, which are related to patients' satisfaction with their dentures, such as level of education, self-perception of economic status as well as the quality of the denture itself.[v] In addition, as Dr Misch wrote in his Contemporary Implant Dentistry textbook, "patient's function when wearing a denture may be reduced to one sixth of that level formerly experienced with natural dentition, however, an implant prosthesis may return the function to near-normal limits".[vi] It comes as no surprise then, that complete edentulism spurred a variety of implant retained prosthetic treatments aiming to reduce discomfort, improve function and increase patient's overall satisfaction. While the ideal number of implants supporting an overdenture is still subject for a debate, treatments such as trans-osseous or osseous implant retained overdentures have all shown to provide a higher satisfaction with functionality, stability, retention and aesthetics when compared to conventional complete lower denture.[vii] A prospective study conducted in the undergraduate clinic at the College of Dentistry, University of Manitoba focused on patient satisfaction with a 3 implant retained lower overdenture and an assessment of peri-implant bone loss comparing to the baseline values. The purposes of this study was to: I) to evaluate subject response to complete lower dentures retained by 3 implants fitted with independent overdenture attachments; II) to evaluate the

efficacy of using a one-piece implant in an academic setting; III) to evaluate bone loss around a one-piece dental implant over several years.

Materials and Methods:

Patients were recruited from the undergraduate clinic at the University of Manitoba. IRB was obtained for this study. As a part of the study, patients were given the opportunity to receive an implant retained mandibular overdenture at a subsidized cost. All patients went through a screening process to ensure they are willing to comply with the program's requirements and are suitable candidates to undergo an implant placement surgery. Panoramic or CBCT radiographs were obtained pre-surgically for each patient to assess the amount of bone available for implant placement.

Inclusion Criteria		Exclusion Criteria
• Subject is completely edentulous on maxilla and mandible for at least a year (w/out dentures)		• History of drug and alcohol abuse, excessive smoking (>1 pack/day)
• Adult age (25 plus) male or female		• Uncontrolled systemic disease: diabetes, etc. that may compromised healing
• Stable medical health		• Irradiated surgical site
• Ability to participate in the study for at least 4 years		• Inadequate bone height and width (re: implant size)
• Able to understand and respond to surveys used in the study		• Inability to undergo minor oral surgery because of health or personal reasons
• Adequate amount of bone in the mandible to receive 3 implants.		• Psychological and handicapped conditions that may hinder 4-year involvement (physical handicap conditions)
		• Severe TMDs related to joint pathology

Table 1: Inclusion & Exclusion Criteria

Table 1 outlines the inclusion and exclusion criteria used during screening. Each patient was to receive three One-Piece GoDirect implants (Implant Direct, Las Vegas NV) placed by either graduate Periodontal or Oral Surgery Residents as well as a set of new complete maxillary and mandibular dentures. Implant placement sites were identical in all patients. One implant was placed at the midline of the mandible while the other two were placed at equal distance bilaterally, at the relative position of teeth #33 and #43. Implants used for this study were 11.5mm or 13mm in length and 3.0mm or 3.7mm in diameter, and had a polished 1.5mm or 3.0mm collar. The dimensions of implant placed were governed by patients' bone and soft tissue volume. A new conventional maxillary denture and mandibular overdenture were fabricated and the implants were loaded approximately 6 months following the surgery. Patients were to return to the faculty 1, 2 and 3 years post loading for a follow-up appointment and a satisfaction survey.

Patient satisfaction was evaluated based on a survey response. Each survey consisted of 7 questions focusing on functionality, appearance as well as ease of placement and removal of both lower and upper dentures. Each question was set up to have a range of preset answers to have a more consistent response and a better gauge of patient's satisfaction. Performance of the implant retained lower denture was then determined based on analysis and comparison of the identified response patterns. Interpretation of the responses was made possible by entering the obtained data into graphs. Surveys that had one or more questions being not applicable, skipped or missed were not included in the analysis.

During the follow-up appointments, peri-implant tissue condition was examined clinically as well as radiographically. Radiographic analysis was performed using digital panoramic imaging on a Kodak CS 9000 machine (Carestream Dental, Rochester, NY). The pre-operative image was used as a reference point and additional panoramic image was taken each subsequent year during the yearly follow-up appointment. Bone level measurements were

obtained using a built in ruler tool in MiPACS Dental Enterprise Viewer software (Medicor Imaging, Charlotte, NC). For each implant, the recorded measurements were adjusted for panoramic distortion. To accomplish that, prior to measuring bone levels, a radiographic measurement of the implant placed was taken. Using this digital measurement and implant length, as stated in patient's clinical records, allowed determining the distortion ratio for each individual implant. Ratio calculation was accomplished by obtaining the length of the implant on the radiograph and dividing it by real implant length, as stated by manufacturer.

For the purpose of this study, length of the implant on the radiograph refers to a reading from the apex of the implant to the visible demarcation immediately above the implant collar. Manufacturers refer to the length as from the apex to the point just below the collar. Collar height (1.5mm or 3.0mm) was added to each of the implant's length. (Eq. 11.5mm implant with 1.5mm collar was considered as 13mm for the purpose of ratio determination) This ratio was then applied to patient's bone level measurements, to bring the obtained value to scale.

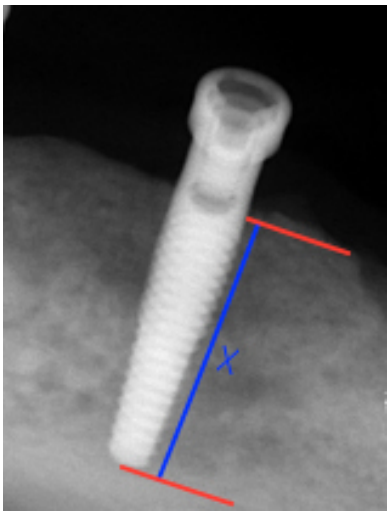

Fig. 1: Bone level measurement on a radiograph.

As shown in Fig. 1, readings of bone levels (x) were obtained from the apex of an implant to the highest point of bone level immediately adjacent to the implant. To verify and quantify the amount of distortion inherit to panoramic

imaging and further confirm operator's accuracy, a metal object similar to an implant and of specific length was used. The screw was placed in a lower jaw of a simulation skull, to better represent the orientation of an implant, and a panoramic image was obtained. The screw's dimensions on the image were then measured using the MiPACS Dental Enterprise Viewer software and physically using a digital caliper to determine the exact distortion ratio.

The amount of distortion could have potentially been affected by position of the implants in the arch in relation to focal trough, a sub-study was conducted to further address the distortion inherent to panoramic imaging. In all patients, each of the 3 implant's distortion ratios was determined separately. The values were then averaged and used to validate the ratios obtained during the main study. In addition, the measurements taken by operator were calibrated in an attempt to account for presence of intra-operator error. The calibration was accomplished by repeated measurement of an implant on a selected panoramic image over a period of several days, as well as repeated measurement of the aforementioned metal screw on a radiograph followed by validation of the measurements by physical determination of object's dimensions.

An ANOVA test comparing the Time, Location and Collar Size to bone loss was performed in order to determine the significance of the means within the analyzed data. Since a smaller P-value carries a larger explanatory power, a P-value of <0.05 was chosen indicating significance. .

Results:

The portion of the patient pool that produced satisfaction survey data was 55%. The study participants lost to follow up was due to due to illnesses, incarceration, death, as well as other personal reasons. The number of collected survey responses was: 24 - 1 year post loading, 14 - 2 years post loading and 4 - 3 years post loading. Only 4 patients consistently showed up for their follow-up appointments and had 3 consecutive years of radiographic and survey data. No statistical analysis was performed for this part of the study due to very small

sample size in year 3, which would make it difficult to have enough power for significant analysis.

Survey analysis was based on the interpretation of Fig. 2 through 4, representing all the responses collected per year. A total of 42 surveys were filled out by 24 patients over the course of 3 years. The overall majority of answers are in the Satisfied to Very Satisfied range. Similar reports were obtained clinically during patients' follow-up appointments.

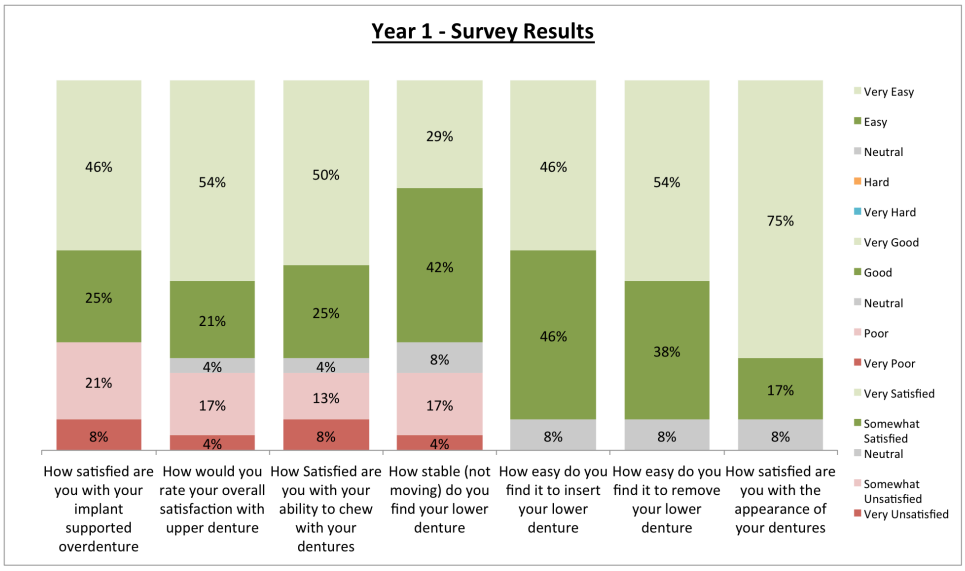

Fig. 2

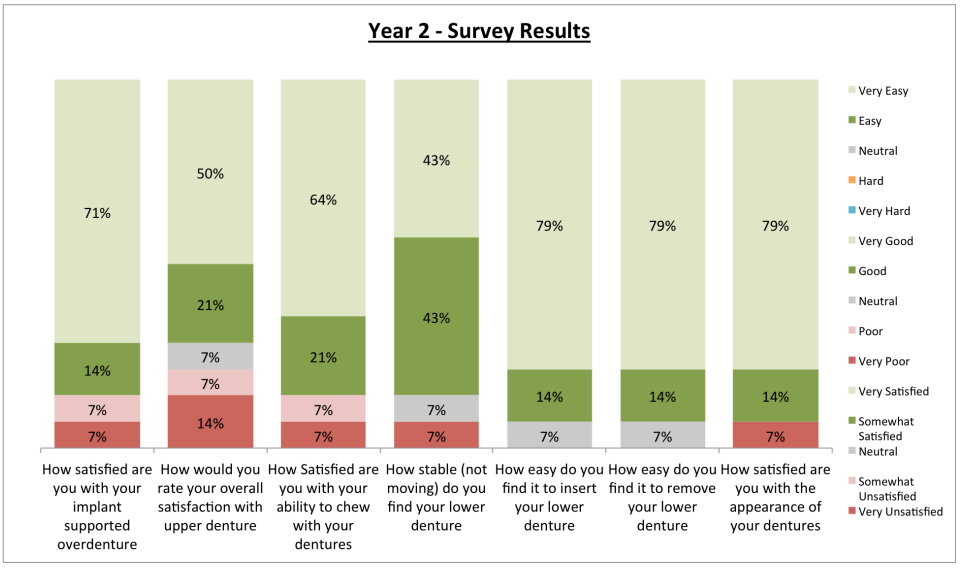

Fig. 3

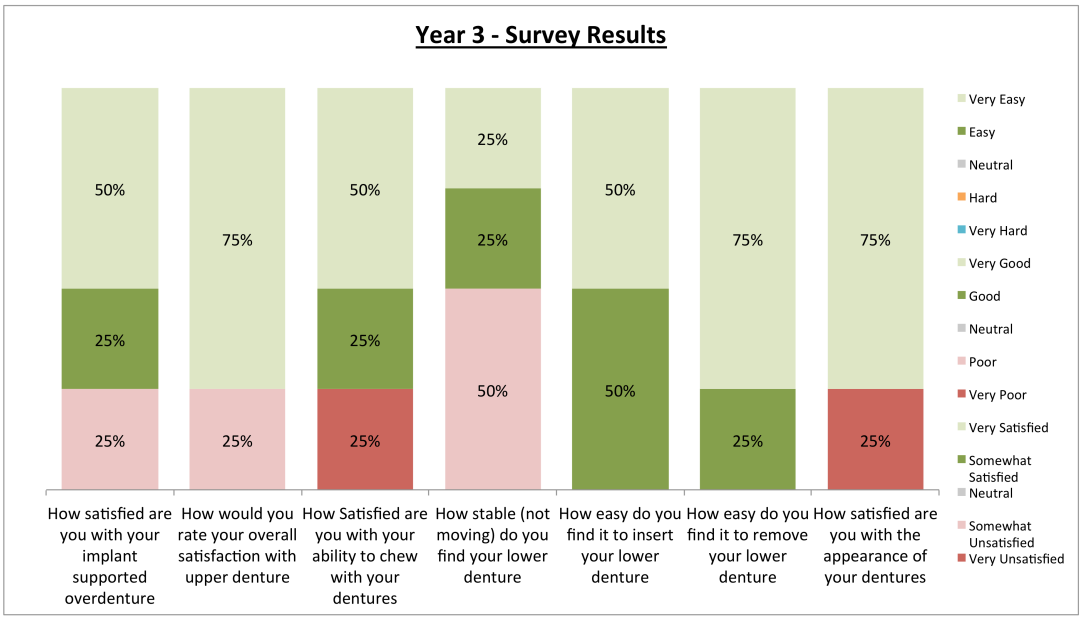

Fig. 4

As presented in Figures 2-4, question #1 dealing with overall satisfaction with implant supported lower denture had an overall positive trend going from 71% satisfaction in year 1 to 85% in year 2 and 75% in year 3. Looking strictly at Maxillary denture, there was a very similar response pattern. Question #2 had 75%, 71% and 75% satisfied patients in years 1, 2 and 3 respectively. Very similar positive pattern of responses was observed for question #3, which focused on the functionality of patients' new dentures. 75% were satisfied with their ability to chew with their new dentures in year 1, and 85% in year 2. Results of year 3 were slightly lower and show same satisfaction rates of 75% as year 1. Comparable responses were also obtained for question #4 looking strictly at the stability of patients' lower denture. It appears that 71%, 86% and 50% were satisfied with the stability of their lower denture in years 1, 2 and 3 respectively. Very positive results were obtained for question #5, where participants found the lower denture easy to insert 92%, 93% 100% of the time in years 1, 2 and 3 respectively. Question #6 had an identical positive pattern of 92%, 93% and 100% for years 1, 2, and 3, yet was excluded from the analysis due to poor wording. Lastly, question #7 had a generally positive set of responses. In year 1

92% of the patients found their dentures to be esthetically pleasing. The number has increased to 93% in year 2, however it dropped to 75% in year 3.

Not all of the participants who have completed the surveys had yearly panoramic radiographs, which resulted in a smaller sample size for the hard tissue stability part of the study. Total of 25 participants had their panoramic images taken post implant placement. A 1-year follow-up radiograph was taken for 23 participants, followed by 11 during the 2-year follow-up. Only the data of patients with consecutive yearly readings was included.

Figures 5 and 6 summarize and represent the change in peri-implant bone levels as they were recorded during yearly follow up appointments. For the purpose of analysis each measurement site was considered as a separate unit. (n = #patients x #implants x 2 reading sites) The values for n in years 1 and 2 were 136 and 66 respectively.

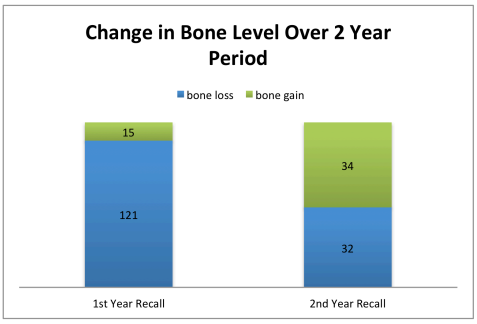

Fig. 5

Data displayed in Figure 5 represents the change in patients' bone levels over the run of the study. 89% of areas measured presented with some degree of bone loss one year post implant placement, reduced to 48% at two years. As expected, bone gain presented with an inverse pattern 11% in year one and 52% in year two. Conforming to accepted clinical standards, the amount of marginal bone loss in year 1 was on average 0.99mm, followed by additional average loss of 0.08mm in the following year. The average amount of loss in sites with bone loss was 1.15mm in year 1 and 0.39mm in year 2. The average amount of gain in sites with bone gain was 0.46mm in year 1 and increased slightly to 0.51mm in year 2. The overall average of bone loss over the 2-year period was 1.1mm and overall gain was 0.66mm.

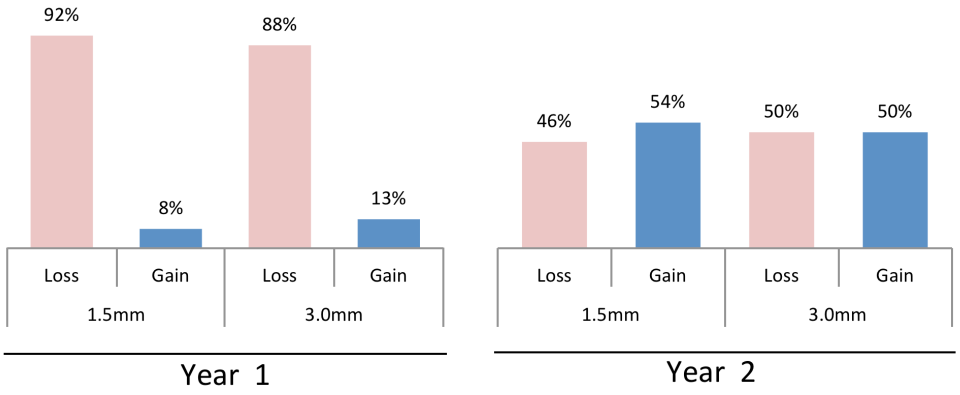

Fig. 6

Overall ANOVA

	DF	Sum of Squares	Mean Square	F Value	P Value
Time	2	87.53046	43.76523	14.83943	6.81738E-7
Tooth	2	9.15737	4.57869	1.55249	0.21329
Size	1	60.90331	60.90331	20.65042	7.7918E-6
Time * Tooth	4	0.67343	0.16836	0.05708	0.99393
Time * Size	2	0.71782	0.35891	0.12169	0.88546
Tooth * Size	2	13.99603	6.99801	2.37281	0.09484
Time * Tooth * Size	4	1.59406	0.39851	0.13512	0.96932
Model	17	194.39684	11.43511	3.87729	6.25711E-7
Error	324	955.55789	2.94925	0	0
Corrected Total	341	1149.95473	0	0	0

At the 0.05 level, the population means of **Time** are **significantly** different.
At the 0.05 level, the population means of **Tooth** are **not significantly** different.
At the 0.05 level, the population means of **Size** are **significantly** different.
At the 0.05 level, the population means of **Time * Tooth** are **not significantly** different.
At the 0.05 level, the population means of **Time * Size** are **not significantly** different.
At the 0.05 level, the population means of **Tooth * Size** are **not significantly** different.
At the 0.05 level, the population means of **Time * Tooth * Size** are **not significantly** different.

Fig. 7: Tree-Way Analysis of interaction between Time, location in the arch (Tooth) and collar height (Size)

An ANOVA test comparing the means of the variables Time, Location and Collar Size to bone loss identified the variables Time and Collar Size as being significant. Both Time and Collar Size variables had a $P<0.05$ (Collar size $P=7.71E-6$, Time $P=6.82E-7$). Based on the analysis, Location variable was not statistically significant.

Figure 6 provides a more detailed view and compares overall bone level changes around the 1.5mm and 3.0mm collar implants that were used. It was noted that, as compared to 3mm collar implants, 1.5mm collar implants had slightly greater instances of bone loss and lower bone gain associated with them in the first year following implant placement. However, at 2-year follow-up the situation reversed, presenting 1.5mm collar implants with lower occurrences of bone loss and higher gain than the 3mm collar implants. Implants with 3mm collars had an average bone loss of 1.25mm and 0.34mm associated with them, while 1.5mm collared implants had an average of 1.07mm and 0.48mm of loss in years 1 and 2 respectively. Bone gain was 0.35mm in year 1 and 0.51mm in year 2 for 3mm collar implant and 0.77mm in year 1 and 0.50mm in year 2 for 1.5mm collar implant.

The adjustment ratio used in the study was determined through the use of implant dimensions provided by the manufacturer and a radiographic reading of implants' length. The lowest adjustment ratio used in this study was 65% while the highest was 71% resulting in an average of 68%. Bearing in mind that the amount of distortion may differ due to position of the implants in the arch, a secondary set of measurements was performed for all patients. Sub-study addressing the panoramic distortion focused on verifying the reliability of determining the adjustment ratio based on a single implant measurement per patient. The overall average adjustment ratio used throughout the main study was 0.68. In the sub-study, the average adjustment ratio value, for measurements obtained separately for each of the three implants at 43, 31 and 33, was 0.64.

The intra-operator calibration performed, allowed verification of the reproducibility of the readings performed throughout the study. An implant on a randomly selected panoramic radiograph was repeatedly measured 10 times over a period of 4 days with the ruler function hidden during the measurement. After each measurement the number value was revealed and recorded. The result was an average value of 33.20mm with standard deviation 0.22 Additional certainty was added by recording an object similar to an implant on a panoramic

radiograph. Object's radiographic length was taken 3 times and the results averaged at 33.42mm with standard deviation of 0.025. The average value was then compared to the physical length of the object which was 22.35mm and was determined using a caliper. The average radiographic length and the physical length were then used to establish the distortion/adjustment ratio to be 0.67.

Discussion:

Multiple treatment and non-treatment related factors are involved in patient's perception of their denture.[viii] Factors such as operator skill level, patient's age, level of education, previous denture wearing experience and others were all found to play a role in denture success.[ix] Having a skilled clinician working with a patient has great potential to minimize dissatisfaction to begin with. However this may not always be sufficient. Although all attempts were made by both the students and their supervising instructors in the Undergraduate Clinic to produce the best final result, some patients still expressed certain level of dissatisfaction with their new denture's function or appearance. (Fig. 1-3, 7)

Overall, the responses collected suggest that the study participants were happy with the outcome, however certain degree of dissatisfaction did exist. Based on the data obtained from figures 1, 2, 3 and 7, it can be observed that the general trend of the responses follows a parabolic pattern. The satisfaction rates appear to increase from year 1 to year 2, followed by a varied degree drop in the subsequent year. One of the potential causes of dissatisfaction could be an unexpected obstacle identified during the follow-up examinations. The retention mechanism originally utilized during this study did not performing as expected. Throughout most of the study a GPS retention component was used to provide retention between the implants and an overdenture. As the program progressed, it was recognized that after a certain period of time the GPS retainer used to secure the lower denture to implants were failing to perform and needed to be replaced during the follow up appointments at a higher rate than was expected. The abutment configuration on the implants used in this program were

compatible with conventional Locators, which were used to replace the failing GPS components. The issue was only recognized towards the end of the program and not all patients had the opportunity to come in for the locator replacement appointment. As a result many patients may have initially had an overall positive experience with their lower denture, up to the point when GPS locators began to fail, causing compromised retention and stability of their denture.

Factors other than retention by the implants could also affect patients satisfaction. The large number of underprivileged patients enrolled in this program could also play a role in lower satisfaction as well as overall low recall rates. When prioritizing between dental appointments and providing the bare minimum for themselves and their families, some patients may compromise their health and only come in for emergency appointments. As a result this sector of a population may remain unhappy with their denture for a longer period of time without having the ability to address the issues. This was also supported by a pattern observed during the follow up appointments. It was noted that as patients returned for an adjustment and had their concerns resolved, their satisfaction increased.

During the interpretation of survey responses it was decided to disregard question #6 which dealt with ease of removal of the lower denture. Although the responses to this question were positive, more often than not patients were unclear whether “easy to remove” should be interpreted as a positive where there is no challenge to remove it, or as a negative where the denture is not retentive enough. In retrospect the wording of the question should have been adjusted to make sure it is clear what it’s asking.

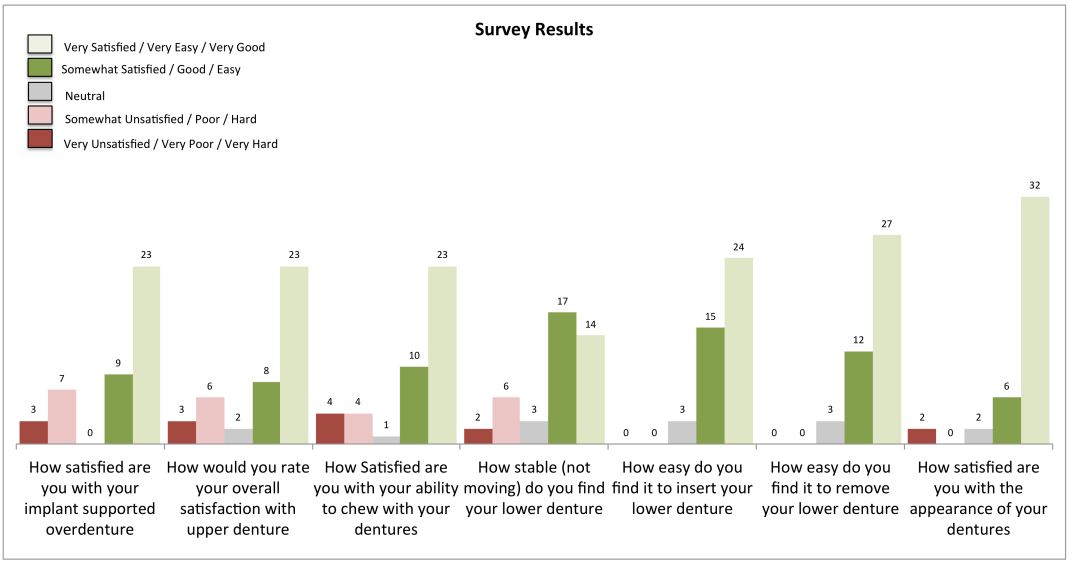

Fig. 8: Overall survey results combined

A fairly high positive response rate was obtained for a question looking strictly into the stability of patients' lower denture (Fig 1-3, 8). Out of all respondents, 74% were somewhat or very satisfied, 7% neutral and 19% somewhat or very unsatisfied. Same rate of satisfaction was observed for the ability to chew with the current set of dentures 79%, 2% and 19% respectively. While not entirely positive, this finding support the hypothesis that stability and function of complete dentures can be improved when supported by implants. The findings were also consistent with the suggestions made by Meijer and De Bruyn in their studies that patient satisfaction with their implant retained lower denture can be considerably higher than with conventional denture.[x] [xi] While some authors favor the 2 implant-retained overdentures for their cost effectiveness [xii], other indicate that there is a noticeable improvement in support and stability of an overdenture with increased number of implants.[xiii] Considering the overall positive outcome, this study could suggest that a 3 implant supported overdenture is a practical alternative to 2 or 4 implants when trying to minimize the financial investment yet increase the stability and retention of a denture.

It is important to note, that as demonstrated by the survey results, there was a nearly equal overall satisfaction with both implant supported lower and complete upper denture (76% and 74%). As mentioned earlier, generally an

upper denture has greater satisfaction rate in terms of patient comfort as well as denture stability, retention and functionality.[xiv] This finding suggests that the treatment modality implemented in this study can be seen as viable to improve the success of implant retained lower denture.

Findings of this study with regards to bone levels once again confirmed the clinically accepted standards of success that were suggested by Albrektsson and colleagues.[xv] According to Albrektsson and Isidor, loss of less than 1.5 mm of bone during the first year post loading, and less than 0.2 mm per year thereafter may be considered a success.[xvi] The results obtained in this study were within those parameters being on average 0.99mm of bone loss at one-year follow-up, followed by stabilization in year 2 with average loss of 0.08mm. The greater amount of bone loss during the first year post implant placement followed by stabilization in the following year (Fig. 5) also paralleled the findings of a study on marginal bone level change around different implant systems, performed by Su-Young Lee et.al. In their study, Su-Young Lee identified that most of the bone loss occurred within the first year post loading, followed by stabilization in following years.[xvii]

Since a calculated adjustment ratio was used to interpret the data required for this study, it was essential to confirm the reliability of the method used to obtain the data. Potential measurement errors throughout the study were addressed to add further validity to this studies results. The ability to expose a screw shaped object on a panoramic radiograph, radiographically determine it's length and then processing the results with a physical measurement obtained with a caliper, allowed to reliably establish the distortion ratio. Considering that all the radiographs for this study were exposed using the same panoramic machine and measured using the same software, it was hypothesized that the distortion ratio for this trial run should not differ from the adjustment ratio used in the main study. As expected, the results were nearly identical with average distortion ratios being respectively 0.67 and 0.68 for this confirmation run and the study. Furthermore, a sub-study was performed during the data analysis to verify reliability of radiographic measurements taken during this study. When making a

panoramic radiograph, measurements may differ based on the position of an implant in the jaw, and the where the focal trough of the radiograph is established. To account for these distortions it was decided to conduct a series of additional measurements to confirm and add reliability to the main study's results. As it was mentioned earlier, the average adjustment ratio values for each of the implants at 43, 31 and 33 were 0.64, while the overall average ratio value in the main study was 0.68. Having the adjustment ratios values so close to each other suggests that in future research a single implant measurement can be performed to obtain a reliable adjustment ratio. In addition it reaffirmed that the original values obtained in the main study were valid.

Researches have hypothesized that similarly to teeth, connective tissue and epithelial tissue attachment also exists around implants forming a biologic seal.[xviii] Although Berglundh found a marked difference in terms of collagen fiber orientation within the peri-implant mucosa, it was found that the tissue acts in the same way creating a biologic seal around the implant.[xix] As it was established by Berglundh and later confirmed by Abramson et al [xx], the soft tissue attachment formed around an implant consisted of roughly 2mm of junctional epithelium and 1mm of connective tissue. As mentioned earlier, there were greater instances of bone loss observed in year one around 1.5mm collar implants as opposed to 3mm. (Fig. 6) One potential reason for this finding could be related to the Biologic Width concept. Hermann stated that, similarly to natural teeth, Biologic Width around implants "..is a physiologically formed and stable structure over time..".[xxi] Since the distance from micro-gap to the alveolar crest in a 1.5mm implant is shorter and invading the biologic width dimension, it could provoke a tissue response as bone will maintain its biologic width and resorb to roughly 2 mm away from micro-gap.[xxii] This is consistent with the results of a study by Tae-Ju Oh and colleagues, who found that one of the reasons for increased vertical bone loss around an implant, could be associated with disruption of the biological seal around the implant.[xxiii] Gargiulo et al identified biologic width in their study of dento-gingival junction in human cadavers. According to their findings, the dimensions were averaging at 2.04mm and accounted for supraalveolar

connective tissue and junctional epithelial attachment.[xxiv] Invasion of this physiological dimension could compromise tissue health and contribute to bone resorption. In their study on the importance of biologic width in periodontal and restorative dentistry, Nugala and colleagues indicate that it plays an important role in isolating and protecting the underlying alveolar tissues from disease and infection.[xxv] Based on Fig.6 the overall pattern changed in year 2 and presented with greater occurrence of bone loss around the 3.0mm versus the 1.5mm collar implants. However, this result could have been affected by the uneven distribution of 3mm and 1.5mm collared implants in the sample. In addition, the overall amount of loss still appeared greater with 1.5mm implants. It was noted that when looking strictly at the amounts of bone loss in year 2 post placement, the average bone loss around a 3mm collar Implant was on average 0.34mm, yet it was 0.48mm around 1.5mm collar implants.

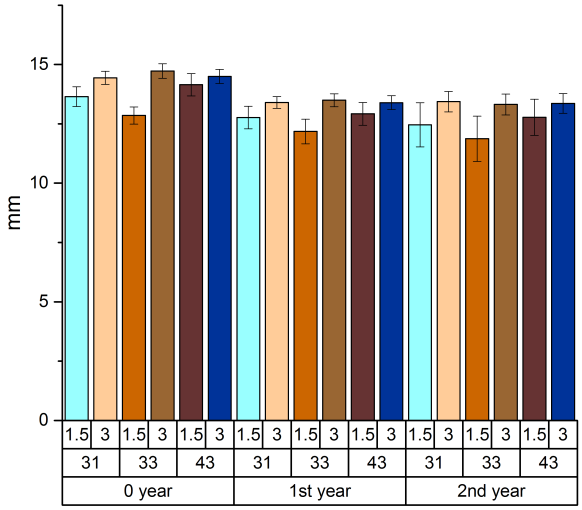

Fig. 9: Bone height vs. Time/Tooth/Size

Based on the statistical analysis there was a significant difference between the 1.5mm and the 3mm collar implants when compared to the amount of bone loss (Collar size P=7.71E-6). Fig. 9 shows that a more significant difference in bone loss was present around a 1.5mm collar implant as compared to a 3mm, thus once again confirming that the smaller collar implants had higher bone loss associated with them. Based on these results, it can be suggested that

use of 1.5mm collar implant could in fact be causing an infringement of the biologic width and contributing to peri-implant bone loss.

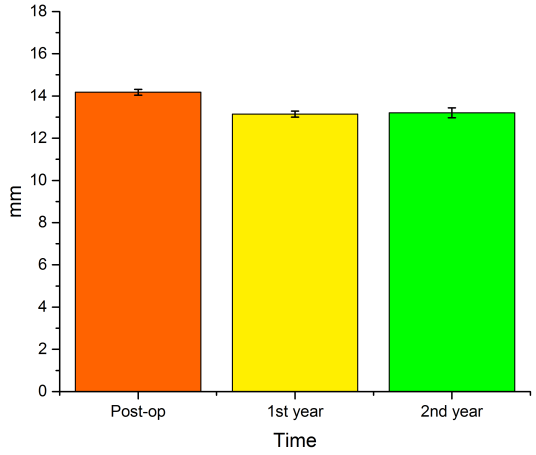

Fig. 10: Bone level vs. Time

The only other significant factor that was isolated in this study was time as similar result was observed with the Time variable (Time P=6.82E-7). The Time variable was significantly different in relation to Bone Loss variable, confirming progression of bone loss with time. However, it is important to note that the significance of Time was only observed when comparing the data of Post-op to Year 1 and Post-op to Year 2. No significant difference was found in the analysis of Year 1 to Year 2 data. As expected, there was a greater loss of crestal bone around all implants during the first year post placement, followed by stabilization in year two. It appears that neither the site of placement nor the site of measurement played a significant role in affecting the bone stability or the end result.

Conclusion:

Despite being a rather short study with fairly small sample size, the study produced some meaningful results. The majority of the patients were satisfied with their mandibular overdenture, as compared to their old conventional denture. Neither the satisfaction nor the retention of the denture appeared to be compromised by being supported by 3 implants. Although not all patients' responses came in positive, the overall report showed satisfaction with lower overdenture retention and stability. Consistent with multiple studies, majority of the participants did find their implant retained lower overdenture to be functional to their satisfaction. Satisfaction survey had an overall positive response suggesting that the techniques utilized throughout the study were effective and may be successfully applied in the future to address patient dissatisfaction with their complete lower denture.

Bone level stability was consistent with the accepted values, with greater loss during the first year, followed by stabilization in subsequent years. The study suggests that the One-Piece GoDirect implants (Implant Direct, Las Vegas NV) are a viable option to serve as abutments for implant retained mandibular overdenture. To the extent of this study, patient's tissue response was as expected, regardless of location of implant placement, size of the implant or specific location of measurement. ANOVA test established that only the variables Time and Collar size had statistically significant difference as compared crestal bone loss. (Collar size P=7.71E-6, Time P=6.82E-7). Peri-implant bone loss throughout the study was consistent with the accepted clinical standards and was on average 0.99mm in year 1, and 0.08mm on average in the following year. In addition, consistent with the Biological Width theory, 3mm collar implants appeared to have reduced amounts of bone loss as opposed to implants with 1.5mm collars.

While a 100% satisfaction wasn't achieved in an undergraduate clinic setting, once applied by an experienced clinician this technique may have a great potential to be highly successful. The results of this study suggest that while

there is room for further improvement on the study design and additional testing, a 3 One-Piece implant supported mandibular overdenture is an acceptable treatment modality in undergraduate setting and has the potential to improve patient satisfaction and provide invaluable experience to students.

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