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# BIOMECHANICAL ANALYSIS OF NORMAL AND IMPLANTED TOOTH USING BITING FORCE MEASUREMENT

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## ABSTRACT:

*Success of dental implant procedure means it restore the function of the teeth just like original one such as chewing, biting, aesthetics and other oral functions. Under normal circumstances, a single freestanding tooth or implant is commonly exposed to chewing forces that are usually compressive. Biting force measurement on the implanted teeth is one of the most important tests to compare the implanted tooth with normal one because the main function performed by teeth is cutting, tearing, crumbling or grinding of food or other materials. Biting force is applied in the loading end of the specially designed transduction device through a disposable polyethylene tubing cover. The biting force values were recorded for the normal subject and the subject having dental implants in their mouth from left molar to the right molar was also compared and presented as line diagram. Data obtained from the biting force experiments with human patients show that the axial forces during biting can range from low value such as 77 N to much higher value such as 2440 N. the lateral force components are much less, e.g., less than 100 N.. From the graphical representation it was clear that the difference in average biting force for both pairs in the normal subject and the subject having dental implant is not large but it was so close that they are not really distinct from each other. This result can be used to design and evaluate any dental prosthesis so far its strength is concerned.*

**Keywords: Biomechanical analysis, Biting force, Chewing, Compressive force, Dental implant. Oral function.**

## INTRODCUTION

Around the world, numbers of individuals have been affected with dental loss, including both young and elderly individuals. The dental surgeons were regularly used dental implants to restore the normal function of teeth. In order to make the mastication function possible, it is necessary to apply appropriate force to the material by the teeth. However, the teeth are the passive element to exert force. Bite force is an important variable to investigate oral function related to occlusal factor, dentition, dentures, and treatment with implants, orthognatic surgery, temporo-mandibular disorders and neuromuscular changes [1]. Muscle force and the number of functional teeth are determinant factors in masticatory. Measuring maximum bite force is an attempt to quantify the force that mandible elevator muscles can make [2]. The biting force is generated by the action of the associated musculature of mandible and maxilla, ultimately transmitted through the teeth on the material which is being bitten or chewed. The forces generated predominantly during biting or chewing function act on the jaw bone in different directions depending on acting of muscles that perform definite action. The various directional forces are 1) vertical forces-usually acting eccentric to the teeth central axis 2) inclined forces- resolved into vertical and horizontal components 3) lateral forces and 4) moments. This biting force is not of same magnitude for each and every pair of teeth that are being used for biting. In dental

surgery the following prosthodontic aspects like dental implant design modalities, strength of the artificial teeth and its efficacies are very much dependent on this factor [3, 4, 5]. Measurement of biting or chewing force is important as very little data regarding this is available in the literature. In this work only the vertical force is measured as this force is the major part of the biting force. We have used the measured force for the purpose of stress analysis of the mandible. Lateral force and others are very small in magnitude compared to the vertical force. The maximum vertical biting force in human was found to approach 800 N [6]. The estimated the lateral forces to be in the order of 20 N [7]. Although the lateral component of inclined force in the incisor region can be appreciable [8]. The quest was the range of forces which a pair of teeth generates during biting. The purpose of this study was to measure the maximal biting forces exerted by the implanted tooth and compare it with the natural teeth, by means of a specially designed transduction device.

## MEASUREMENT OF BITING FORCE

Bite force is one indicator of the functional state of the masticatory system that results from the action of jaw elevator muscles modified by the craniomandibular biomechanics [9]. Determination of individual bite force level has been widely used in dentistry, mainly to understand the mechanics of mastication for evaluation of the therapeutic effects of prosthetic devices and to provide reference values for studies on the biomechanics of prosthetic devices [10]. In addition, bite force has been considered important in the diagnosis of the disturbances of the stomatognathic system [11].

Biting force measurement on the implanted teeth is one of the most important tests to compare the implanted tooth with normal one because the main function performed by teeth is cutting, tearing, crumbling or grinding of food or other materials [12]**.** Both male and female subjects were selected in the age range of 50-65 years. All subjects were in good health with no medical problem and they were informed about the aim of the study, and informed consent was supplied according to the ethical guidelines of the KPC Medical College and Hospital. The subjects sitting upright in a chair and the transduction device kept on a table is placed in front. Then they were asked to bite as strong as possible, up to the maximal bite force and to release immediately after that. Biting force is applied in the loading end of the specially designed transduction device through a disposable polyethylene tubing cover as desired. The cover sleeve is changed after each measurement on a subject to avoid contamination from saliva. The subject seated in a chair in appropriate posture was asked to apply maximum possible biting force. The biting force was measured for fifteen subjects experimentally for every pair of their teeth facing each other and the results were recorded.

The procedure of biting force measurement was shown in Figure-1 & Figure-2.

**Fig-1: Measuring the maximum biting force for a normal subject**

**2(a)**

2(b)

**Fig-2: Measurement of Biting Force after implantation (a) subject with titanium implanted teeth already fixed in anterior areas (Incisors) (b) subject with titanium implanted teeth already fixed in posterior region (molar teeth).**

**RESULTS OF BITING FORCE MEASUREMENT:**

The biting force values were recorded for the normal subject and the subject having dental implants in their mouth from left most to the right most was also compared and presented as line diagram (Fig-7). The average value of vertical biting force for each pair of teeth in normal subject and the subject having dental implants were listed in Tables 1, 2, 3, 4, 5 and 6. In the graphical representation, the variations of biting force over the mandible were shown. The figure show the average values along with their standard deviations. The measured force is given in Newton (N). In the incisor region of the normal subject the mean force is found to be around 193 N and the mean force value obtained in the molar (M3) region is 350 N. but ate implantation it was found that the mean force value is 188 N and 323 N in the region of incisor and molar respectively.

**Table-1: Biting Force in Newton for Central Incisor ($I_C$), Lateral Incisor ($I_L$) and Canine(C):**

| Subject (M/F-age) | $I_C$ | | $I_L$ | | C | |
|---|---|---|---|---|---|---|
| | L | R | L | R | L | R |
| F-55 | 111 | 119 | 130 | 145 | 145 | 137 |
| F-53 | 220 | 180 | 240 | 253 | 275 | 263 |
| M-64 | 265 | 260 | 230 | 180 | 250 | 269 |
| M-55 | 188 | 181 | 139 | 142 | 162 | 174 |
| M-65 | 193 | 210 | 150 | 189 | 200 | 190 |
| M-57 | 250 | 265 | 252 | 265 | 265 | 272 |
| M-54 | 123 | 132 | 202 | 214 | 193 | 201 |
| M-56 | 199 | 218 | 160 | 172 | 254 | 272 |
| M-58 | 190 | 200 | 230 | 225 | 250 | 265 |
| F-55 | 154 | 167 | 221 | 232 | 235 | 251 |
| Mean | 189.3 | 193.2 | 195.4 | 201.7 | 222.9 | 229.4 |
| S.d | 49.71 | 48.10 | 46.02 | 42.87 | 45.05 | 49.47 |

**Table-2: Biting Force in N for Central Incisor ($I_C$), Lateral Incisor ($I_L$) and Canine(C) after dental implantation:**

| Subject (M/F-age) | $I_C$ | | $I_L$ | | C | |
|---|---|---|---|---|---|---|
| | L | R | L | R | L | R |
| F-63 | 155 | 143 | 152 | 163 | 205 | 212 |
| M-54 | 159 | 167 | 170 | 158 | 192 | 199 |
| F-53 | 161 | 172 | 230 | 223 | 230 | 235 |
| M-65 | 169 | 179 | 193 | 185 | 252 | 254 |
| M-62 | 171 | 187 | 181 | 193 | 217 | 205 |
| M-63 | 238 | 250 | 179 | 205 | 208 | 193 |
| M-65 | 182 | 168 | 194 | 210 | 207 | 223 |
| M-55 | 198 | 211 | 183 | 192 | 197 | 216 |
| M-64 | 177 | 190 | 191 | 184 | 212 | 218 |
| M-57 | 202 | 211 | 179 | 192 | 229 | 219 |
| Mean | 181.2 | 187.8 | 185.2 | 190.5 | 214.9 | 217.4 |
| S.d | 25.39 | 30.02 | 20.03 | 19.84 | 17.85 | 17.65 |

**Table-3: Biting Force in N for Premolar Teeth ($PM_1$ and $PM_2$):**

| Subject | $PM_1$ | | $PM_2$ | |
|---|---|---|---|---|
| | L | R | L | R |
| F-55 | 223 | 235 | 255 | 278 |
| F-53 | 305 | 340 | 326 | 355 |
| M-64 | 224 | 243 | 320 | 339 |
| M-55 | 280 | 270 | 315 | 295 |
| M-65 | 262 | 245 | 250 | 264 |
| M-57 | 321 | 337 | 271 | 295 |
| M-54 | 311 | 322 | 223 | 205 |
| M-56 | 370 | 348 | 255 | 264 |
| M-58 | 232 | 240 | 226 | 242 |
| F-55 | 302 | 314 | 325 | 330 |
| Mean | 283 | 289.4 | 276.6 | 286.7 |
| S.d | 48.04 | 46.94 | 41.16 | 46.18 |

**Table-4: Biting Force in N for Premolar Teeth ($PM_1$ and $PM_2$) after implantation:**

| Subject | $PM_1$ | | $PM_2$ | |
|---|---|---|---|---|
| | L | R | L | R |
| M-63 | 248 | 267 | 251 | 267 |
| F-52 | 275 | 291 | 273 | 285 |
| F-58 | 323 | 310 | 320 | 326 |
| M-65 | 293 | 287 | 262 | 275 |
| F-62 | 265 | 282 | 270 | 266 |
| M-63 | 257 | 274 | 257 | 249 |
| M-55 | 311 | 329 | 313 | 305 |
| M-65 | 269 | 261 | 245 | 261 |
| M-64 | 261 | 254 | 293 | 282 |
| M-55 | 309 | 314 | 289 | 325 |
| Mean | 281.1 | 286.9 | 277.3 | 284.1 |
| S.d | 26.02 | 24.49 | 25.68 | 26.54 |

**Table-5: Biting Force in N for Molar Teeth ($M_1$, $M_2$ and $M_3$):**

| Subject | $M_1$ | | $M_2$ | | $M_3$ | |
|---|---|---|---|---|---|---|
| | L | R | L | R | L | R |
| F-55 | 280 | 290 | 276 | 281 | 286 | 303 |
| F-53 | 329 | 315 | 308 | 322 | 310 | 325 |
| M-64 | 285 | 291 | 307 | 296 | 324 | 353 |
| M-55 | 390 | 392 | 381 | 385 | 374 | 380 |
| M-65 | 312 | 295 | 293 | 297 | 299 | 313 |
| M-57 | 340 | 352 | 381 | 380 | 340 | 350 |
| M-54 | 335 | 345 | 360 | 375 | 350 | 342 |
| M-56 | 350 | 336 | 362 | 352 | 343 | 367 |
| M-58 | 350 | 357 | 322 | 325 | 331 | 356 |
| F-55 | 345 | 332 | 358 | 352 | 362 | 360 |
| Mean | 331.6 | 330.5 | 334.8 | 336.5 | 331.9 | 344.9 |
| S.d | 32.62 | 33.15 | 38.07 | 37.76 | 27.74 | 24.36 |

**Table-6: Biting Force in N for Molar Teeth ($M_1$, $M_2$ and $M_3$) after implantation:**

| Subject | $M_1$ | | $M_2$ | | $M_3$ | |
|---|---|---|---|---|---|---|
| | L | R | L | R | L | R |
| F-65 | 270 | 293 | 279 | 289 | 286 | 293 |
| F-53 | 312 | 295 | 329 | 318 | 310 | 332 |
| M-64 | 287 | 311 | 276 | 294 | 285 | 293 |
| M-65 | 310 | 302 | 281 | 285 | 304 | 290 |
| M-55 | 342 | 351 | 398 | 382 | 362 | 347 |
| M-57 | 361 | 340 | 321 | 339 | 323 | 346 |
| M-64 | 295 | 315 | 290 | 317 | 321 | 332 |
| M-56 | 323 | 307 | 331 | 323 | 325 | 337 |
| M-59 | 320 | 337 | 322 | 327 | 324 | 336 |
| F-58 | 326 | 331 | 338 | 346 | 312 | 319 |
| Mean | 314.6 | 318.2 | 316.5 | 322.0 | 315.2 | 322.5 |
| S.d | 26.45 | 20.25 | 37.31 | 29.39 | 22.07 | 22.45 |

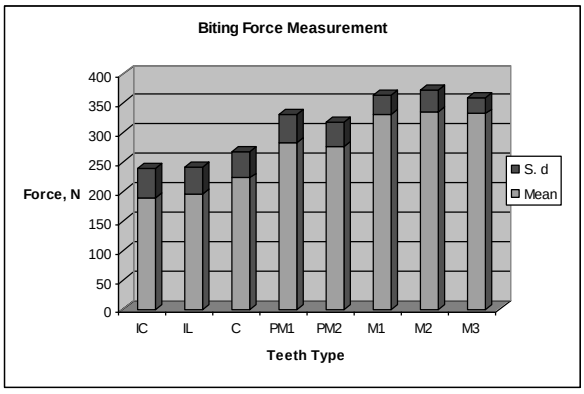


**Fig-3: Biting Force generated on the left side of the normal teeth.**

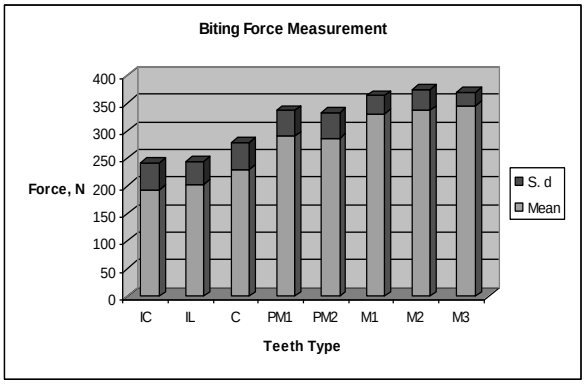


**Fig-4: Biting Force generated on the right side of the normal teeth.**

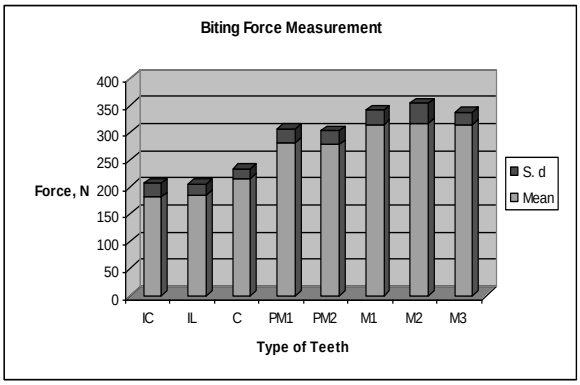


**Fig-5: Biting Force generated on the left side of teeth after implantation**

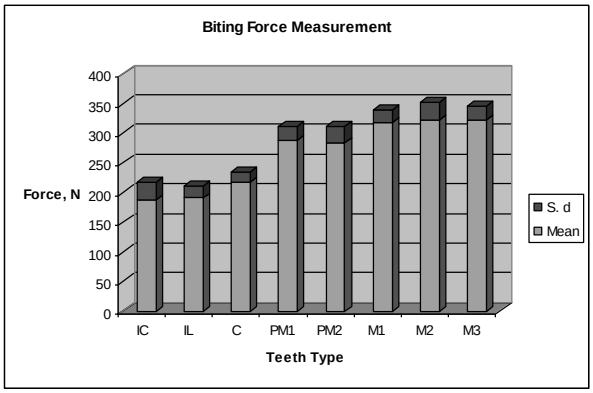


**Fig-6: Biting Force generated on the right side of teeth after implantation**

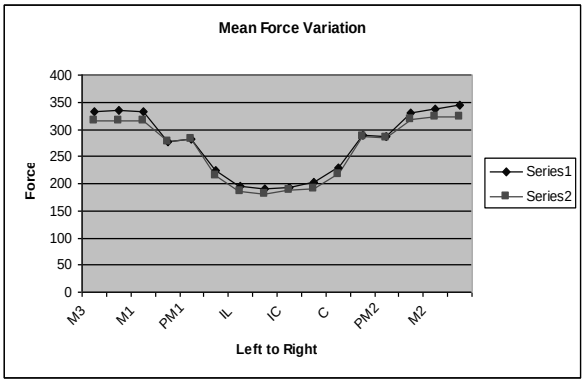


**Fig-7: Comparison of Biting Force generated on natural and implanted teeth from left to right.**

From the graphical representation it was clear that the difference in average biting force for both pairs in the normal subject and the subject having dental implant is not large but it was so close that they are not really distinct from each other**.** The force value in left pair and right pairs are almost identical in both cases. So for lost tooth replacement Titanium Dental implant is the best means as it is superior in every respect, like aesthetics, comfort, function and acceptance.

## CONCLUSION:

From the above mentioned experiment it was clear that forces are evenly distributed on the left and right side of the jaw. It was also observed that the biting force was higher in the posterior pairs of teeth and comparatively lower in the anterior pairs. In other words it can be said that the biting force is inversely varying to the distance of tooth pair from the temporomandibuler joint. This experimental data can be helpful in biomechanical analysis of the mandible for prosthodontist. This result can be used to design and evaluate any dental prosthesis so far its strength is concerned. The stress analysis using Finite Element Method for individual tooth can also be performed using the measured forces, if the dental geometry could be represented.

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