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*Article*

# SET-UP: COMPARISON BETWEEN MANUAL AND DIGITAL METHODS

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## ABSTRACT

The aim of this study is to compare the results in terms of accuracy and outcome of a group of manual set-ups with a group of set-ups performed with digital software. A clinical case of an adult patient was selected with a skeletal class I (with a slight tendency to a skeletal class III), normodivergent, with normoinclination of the upper and lower incisors. The following was performed, starting from the plaster models or digital models of the patient: 10 manual set-ups by 5 dental technicians (each dental technician repeated the set-up twice with an average interval between the first and second set-up of 2 weeks), and 10 digital set-ups by 5 orthodontists with 3Shape software (each orthodontist repeated the set up twice with an average interval between the first and second set-up of 2 weeks). Intra and inter-arch parameters were evaluated and analysed for each manual and digital set-up. The sample includes 560 pairs of measurements (TIP, TORQUE) according to the following scheme: the TIP and TORQUE of 10 manual set-ups of 28 dental elements for each tooth were evaluated; a total of 5 operators carried out the sample of 10 manual set-ups; therefore each operator performed two set-ups, the coefficient of the agreement was equal to 0.49 for the TIP and 0.37 for the TORQUE between the first test and the second test. The TIP and TORQUE of 10 digital set-ups of 28 dental elements for each tooth were evaluated; a total of 5 operators carried out the sample of 10 digital set-ups, and the concordance coefficient was equal to 0.57 for the TIP and 0.96 for the TORQUE between the first test and the second test. The average difference for TIP was greater than ($p<0.0001$) with the manual set-up (average 4.2, SD 4.6) than with the digital set-up (average 2.7, SD 2.7). The average difference for TORQUE was also higher ($p<0.0001$) with the manual set-up (average 8.1, SD 8.4) than with the digital set-up (average 3.7, SD 3.2). The digital set-up proved to be more precise than the manual set-up for all the variables examined with correct values of OB and OJ, flattened Spee and Wilson curves, coincident midlines, correct occlusal relationships, close interproximal contacts, absence of diastemas and relationships intra and inter-arch.

**KEYWORDS:** *orthodontic, set-up, manual, digital, diagnosis, 3Shape*

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## INTRODUCTION

In recent years, the orthodontic set-up has been the subject of great attention and has known many evolutions, especially in the digital era. However, it is certainly not a recent technique; it has been known and used in orthodontics for many decades (1). The first publication by Dr Harold D. Kesling in the *American Journal Of Orthodontics and Oral Surgery* dates back to 1945 and describes a technique used to build a particular device called a "Tooth Positioning Appliance". The technique of preparing a set-up, manual or digital, involves the segmentation of the dental elements and their subsequent repositioning according to the objectives of the orthodontic treatment. The execution of a set-up can have various purposes:

- represents an aid in the diagnostic phase by prefiguring the desired result;
- allows to assess the need for dental extractions;
- allows to predict the necessary interproximal reduction and its location;
- allows to assess what the distribution of spaces should be in pre-prosthetic cases and cases with agenesis;
- is used in the construction of orthodontic devices;
- allows indirect bonding technique in lingual orthodontics.

The diagnostic set-up, in some cases, represents support; in other cases, it is a fundamental and essential diagnostic instrument, it allows an accurate three-dimensional evaluation of the final objectives of the treatment, and there is no linear evaluation or measurement that can replace it (2-10).

*Criteria for the execution of digital and manual set-ups*

For the first time, the *Orthodontic Set Up* text by the authors G. Scuzzo, L. Lombardo and K. Takemoto clearly defines all the intra- and inter-arch dental criteria and the gnathological criteria that allow a correct set-up to be performed (11).

- The intra-arch criteria represent the objectives to be achieved within the upper and lower arches of the individual dental elements and the relationship between them: tip, torque, in and out, contact points, rotations, intercanine diameter, length and shape of the arch.
- The set-up must respect the inter-arch criteria, namely the criteria that derive from the relationship between the dental elements of one arch with those of the other: occlusal contacts, the position of the first molar, canines and incisors, overbite, overjet, the relationship between mesio-distal measurements of the elements of both arches.
- The set-up must respect the gnathological criteria: Wilson curve, Spee curve and disclusion.

*Execution of the manual set-up*

In the Orthodontic Set-Up text, 6 distinct phases of realisation of the manual set-up must be carried out with great accuracy and precision for the success of the result:

- execution of accurate impressions;
- creation of the plaster models of the two arches;
- separation of the dental elements;
- preparation of the articulator;
- positioning of the upper and lower arch teeth with wax;
- occlusal checks and eventual adjustments.

**Fig. 1.** *Extraoral records*

*Execution of the digital set-up*

The digital set-up is performed thanks to software on virtual models starting from physical plaster models subsequently scanned or from models that have been created directly by scanning the arches thanks to intra-oral scanners (12).

Here the accuracy of manual and digital set-up are compared.

## MATERIALS AND METHODS

*Sample selection*

In the present study, we selected the case of an adult patient who presents a skeletal class I (with a slight tendency to skeletal class III), normodivergent, with normoinclination of the upper and lower incisors (Fig. 1-3).

Starting from plaster and digital models of the patient were performed: 10 manual set-ups by 5 dental technicians (each dental technician repeated the set-up twice with an average interval between the first and second set-up of 2 weeks), and 10 digital set-ups by 5 orthodontists with 3Shape software (each orthodontist repeated the set-up twice with an average interval between the first and second set-up of 2 weeks).

*Execution of the diagnostic manual and digital set-up*

For the execution of the manual set-ups, 5 dental technicians specialised in orthodontics were chosen and were asked to perform a total of 10 manual set-ups. The prescription request was to reach the criteria for an ideal occlusion according to the 6 Andrews keys. After performing the set-up, the dental technicians indicated whether interproximal reduction had been used and, if so, specified the location and extent. In addition, five orthodontists with experience performing digital set-ups were asked to execute 2 digital set-ups of the same patient with the 3Shape Orthoanalyzer software. For all the set-ups, STL files were created and imported into the Nemocast software and the 3shape Orthoanalyzer software for analysis.

**Fig. 2.** *Intraoral records*

*Statistical analysis*

In the first approach, the numerical value of the difference was studied. A multifactorial variance model investigated the effects of technique (manual, digital) and tooth position on differences for TIP and TORQUE. In the second approach, data on the difference was reprocessed in terms of "relevant differences" (> 3 °) for each tooth (measurements that deviate from the range of Andrews' normal values). The effects of the technique (manual, digital) and the tooth position on the presence of differences detected for TIP and TORQUE were studied with a logistic model, with an estimation of the OddsRatio (OR) and the respective 95% confidence intervals (95% CI). The third approach analysed the information on "relevant differences" for each mouth. The technique's effects (manual, digital) on the number of teeth with a significant difference was studied on 28 teeth per mouth with a Poisson model. A p-value lower than 0.05 was considered significant. Statistical analysis was performed with R 3.2.2 language.

## RESULTS

The sample includes 560 pairs of measurements (TIP, TORQUE) according to the following scheme: the TIP and TORQUE of 10 manual set-ups of 28 dental elements for each tooth were evaluated; a total of 5 operators carried out the sample of 10 manual set-ups; therefore each operator performed two set-ups, the coefficient of the agreement was equal to 0.49 for the TIP and 0.37 for the TORQUE between the first test and the second test. The TIP and TORQUE of 10 digital set-ups of 28 dental elements for each tooth were evaluated; a total of 5 operators carried out the sample of 10 digital set-ups, and the concordance coefficient was equal to 0.57 for the TIP and 0.96 for the TORQUE between the first test and the second test. The average difference for TIP was greater than ($p<0.0001$) with the manual set-up (average 4.2, SD 4.6) than with the digital set-up (average 2.7, SD 2.7). The average difference for TORQUE was also higher ($p<0.0001$) with the manual set-up (average 8.1, SD 8.4) than with the digital set-up (average 3.7, SD 3.2). In Table I, the results of the manual and digital techniques are reported.

*Intra-arch diameters*

As for the manual set-up group, in the upper arch occurs a general contraction of the arches in the middle and posterior sectors. The upper 3-3 diameter remained virtually unchanged. The lower diameters were respected except at levels 5-5, where there was a slight expansion on average. The digital set-up group is characterised by a generally more significant expansion of transverse diameters, especially at the level of the lower arch.

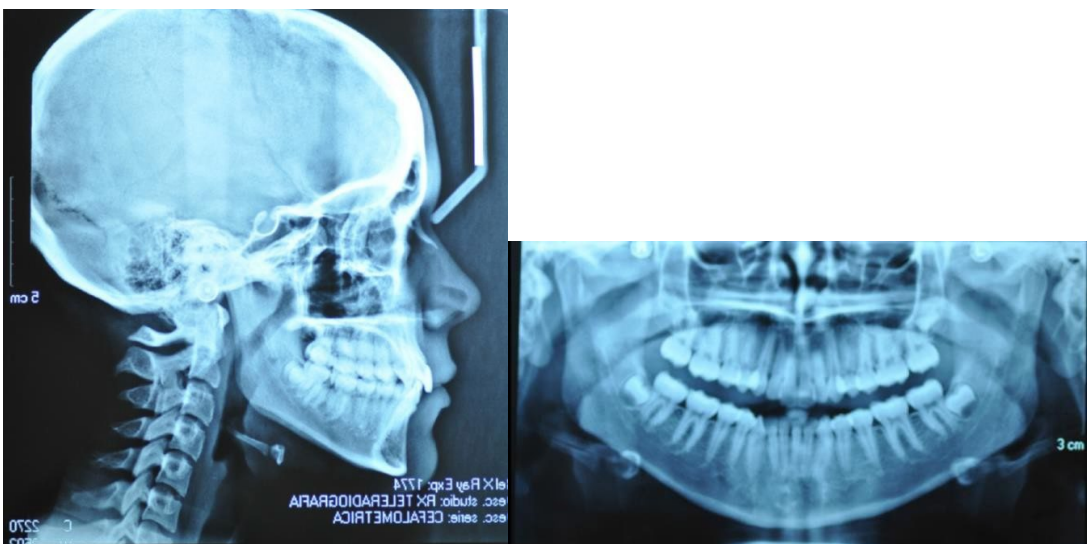


**Fig. 3.** *Radiological records*

**Table I.** *Results of the manual and digital technique*

| **I-Symmetry of the upper and lower arches of the setups** | | | | | |
|---|---|---|---|---|---|
| MANUAL | Symmetry | DIGITAL | Symmetry | | |
| **1 a** | L | **1 a** | YES | | |
| **1 b** | YES | **1 b** | YES | | |
| **2 a** | L | **2 a** | U; L | | |
| **2 b** | L | **2 b** | YES | | |
| **3 a** | YES | **3 a** | YES | | |
| **3 b** | U; L | **3 b** | YES | | |
| **4 a** | L | **4 a** | L | | |
| **4 b** | U | **4 b** | YES | | |
| **5 a** | U; L | **5 a** | L | | |
| **5 b** | U; L | **5 b** | YES | | |
| **II-Spee Curve** | | | | | |
| MANUAL | L (mm) | R (mm) | DIGITAL | L (mm) | R (mm) |
| **1 a** | 0 | 0 | **1 a** | 0 | 0 |
| **1 b** | 0 | 0 | **1 b** | 0 | 0 |
| **2 a** | 2.65 | 1.92 | **2 a** | 0.7 | 0.6 |
| **2 b** | 2.1 | 2 | **2 b** | 0.6 | 0.5 |
| **3 a** | 0 | 0 | **3 a** | 0 | 0 |
| **3 b** | 0 | 0 | **3 b** | 0 | 0 |
| **4 a** | 2.4 | 1.88 | **4 a** | 0 | 0 |
| **4 b** | 2.15 | 2.7 | **4 b** | 0 | 0 |
| **5 a** | 0 | 0 | **5 a** | 0 | 0 |
| **5 b** | 0.7 | 0.83 | **5 b** | 0.5 | 0.5 |
| **III-Wilson Curve** | | | | | |
| MANUAL | L (mm) | R (mm) | DIGITAL | L (mm) | R (mm) |
| **1 a** | 1.61 | 0.73 | **1 a** | 1.91 | 1.84 |
| **1 b** | 1.3 | 1.43 | **1 b** | 2.3 | 1.45 |
| **2 a** | 3.66 | 2.74 | **2 a** | 1.9 | 1.83 |
| **2 b** | 3.9 | 3.85 | **2 b** | 1.78 | 1.89 |
| **3 a** | 2 | 1.1 | **3 a** | 1.81 | 1.63 |
| **3 b** | 0.9 | 1.2 | **3 b** | 1.96 | 1.75 |
| **4 a** | 2.4 | 1.88 | **4 a** | 1.58 | 1.32 |
| **4 b** | 2.36 | 2.8 | **4 b** | 2 | 1.49 |
| **5 a** | 1.92 | 1.81 | **5 a** | 1.8 | 1.5 |
| **5 b** | 1.98 | 2.98 | **5 b** | 1.66 | 1.85 |
| **IV-Interproximal contacts** | | | | | |
| MANUAL | Diastema | | DIGITAL | Diastema | |
| **1 a** | YES | | **1 a** | NO | |
| **1 b** | NO | | **1 b** | NO | |
| **2 a** | NO | | **2 a** | NO | |
| **2 b** | NO | | **2 b** | NO | |
| **3 a** | YES | | **3 a** | NO | |
| **3 b** | YES | | **3 b** | NO | |
| **4 a** | YES | | **4 a** | NO | |
| **4 b** | YES | | **4 b** | NO | |
| **5 a** | YES | | **5 a** | NO | |
| **5 b** | YES | | **5 b** | NO | |

| **V-Arch lenght** | | | | | |
|---|---|---|---|---|---|
| MANUAL | U | L | DIGITAL | U | L |
| **1 a** | 44 | 38.5 | **1 a** | 42.09 | 37.32 |
| **1 b** | 44 | 39.5 | **1 b** | 42.15 | 37.5 |
| **2 a** | 44.2 | 38 | **2 a** | 42.42 | 37.15 |
| **2 b** | 44.11 | 38.5 | **2 b** | 42.12 | 37.36 |
| **3 a** | 44.51 | 39.21 | **3 a** | 42.16 | 37.58 |
| **3 b** | 44.1 | 38.5 | **3 b** | 41.87 | 37.61 |
| **4 a** | 44 | 39.19 | **4 a** | 42.59 | 37.3 |
| **4 b** | 44.81 | 38.98 | **4 b** | 42.64 | 37.63 |
| **5 a** | 44 | 38.08 | **5 a** | 41.9 | 37.37 |
| **5 b** | 42.8 | 37.1 | **5 b** | 42.21 | 36.9 |
| Average | 44.053 | 38.556 | Average | 42.215 | 37.372 |
| St.Dv. | 0.51 | 0.71 | St.Dv. | 0.26 | 0.22 |
| **VI-Interproximal reduction** | | | | | |
| MANUAL | IPR | DIGITAL | IPR | | |
| **1 a** | NO | **1 a** | YES | | |
| **1 b** | NO | **1 b** | YES | | |
| **2 a** | NO | **2 a** | NO | | |
| **2 b** | NO | **2 b** | NO | | |
| **3 a** | YES | **3 a** | YES | | |
| **3 b** | YES | **3 b** | YES | | |
| **4 a** | YES | **4 a** | YES | | |
| **4 b** | NO | **4 b** | YES | | |
| **5 a** | YES | **5 a** | NO | | |
| **5 b** | YES | **5 b** | NO | | |
| **VII-Overjet and Overbite** | | | | | |
| MANUAL | 0B (mm) | OJ (mm) | DIGITAL | 0B (mm) | OJ (mm) |
| **1 a** | 2.7 | 3.5 | **1 a** | 1.7 | 1.9 |
| **1 b** | 2.1 | 3.2 | **1 b** | 2.4 | 2.1 |
| **2 a** | 3.7 | 4.5 | **2 a** | 2.3 | 2.3 |
| **2 b** | 4.2 | 2.9 | **2 b** | 2.7 | 2.2 |
| **3 a** | 2 | 2,9 | **3 a** | 2 | 1.5 |
| **3 b** | 3.2 | 4 | **3 b** | 1.7 | 2.1 |
| **4 a** | 3.9 | 3.9 | **4 a** | 1.9 | 2.5 |
| **4 b** | 3.7 | 3.3 | **4 b** | 2 | 2 |
| **5 a** | 2.1 | 2.2 | **5 a** | 1.3 | 2.3 |
| **5 b** | 2.3 | 2.4 | **5 b** | 2.3 | 2.2 |
| Average | 2.99 | 3.28 | Average | 2.03 | 2.11 |
| St.Dv. | 0.84 | 0.72 | St.Dv. | 0.84 | 0.72 |

*Canine and molar class*

In the manual set-up group, 7 out of 10 cases remain an incomplete class correction at the molar or canine level, with a slight tendency to a skeletal class II. On the other hand, the digital set-up group showed the class correction at the canine and molar levels in all cases.

*Midlines*

The midlines are all correctly centred in the digital set-up group, while in the manual set-up group, 4 out of 10 showed various degrees of deviation.

## DISCUSSION

From the bibliographic review, several studies have been published in which digital set-ups were used to aid the formulation phase of the treatment plan; only two studies compare the digital set-ups with the manual set-ups and evaluate their precision. The first study, published in AJODO by Korean researchers (12), compares the digital set-ups with the manual set-ups in 10 extraction cases; for each patient, a manual and a digital set-up was performed. This study concludes that there is no significant difference between manual and digital set-ups between intra-arch measurements and inter-arch occlusal variables. This data contrasts with the results of the present study in which the digital set-up technique proved to be more precise for all the variables examined. These differences can be explained at least in part by operator-dependent reasons. In the study carried out by Korean researchers, the manual and digital set-ups were carried out by the same operator, while the present study considered the manual and digital set-ups made for a single case by different operators.

The second study comparing the digital set-up with the manual set-up was published in 2015 by a group of Brazilian researchers (13); this work examines the cases of 20 adult patients who had already completed the treatment for each patient with a digital set-up and a manual set-up were performed which were compared with the final models of the patients upon completion of the orthodontic treatment. Only three linear measurements were made: intercanine diameters, intermolar diameters and arch length. The study revealed no significant differences between the measurements, indicating that digital set-ups are equally effective and accurate as diagnostic and treatment planning tools. In this study, only a few linear measurements are considered without evaluating all the intra- and inter-arch parameters that define the result from a qualitative point of view of a set-up.

According to a study (14), the measurements performed on digital 3D models represent valid and reliable alternatives to those performed on physical models with a significant advantage in reduced execution times. Furthermore, according to Sousa et al., digital models were reliable and comparable to physical models to obtain the most common measurements in orthodontic diagnostics (15).

## CONCLUSIONS

The digital set-up group show the TIP and TORQUE values, on average, more correct and close to the standard value in a statistically significant way.

The digital set-up proved to be more precise than the manual set-up for all the variables examined with correct values of OB and OJ, flattened Spee and Wilson curves, coincident midlines, correct occlusal relationships, close interproximal contacts, absence of diastemas and relationships intra and inter-arch.

The manual set-up group saw a strong decrease in the mesio-distal diameters of the elements and the presence of diffuse diastematures, suggesting that the separation of the dental plaster elements did not occur correctly and the interproximal anatomy was not respected.

The digital set-up allows for overcoming some important limitations of the manual method, minimising the possibility of introducing errors during the process and allowing the orthodontist to play a leading role in its execution.

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