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3D analysis of the upper and lower arches using digital technology: measurement of the index of Bolton and correspondence between arch shape and orthodontic arches

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Abstract: Introduction: Due to the great development of digital technology, through CAD (Computer - Aided Design) and CAM (Computer - Aided Manufacturing) systems, digital models could be used in orthodontic treatment planning decision-making, as there are numerous studies in the literature that support the validity of measurements of digital models of anterior teeth and the total coefficient of Bolton analysis. The advantage of digitising the dimensions of teeth for space analysis is that a computer can quickly provide measurements within the arch, between the arches and of individual teeth, and it is also possible to obtain an accurate measurement of the width of each tooth, the sum of the widths of the incisors in each arch and the sum of the widths of all teeth can be compared with the sums of the other arch, and it is possible to place the digital models on the sagittal plane and orient them and obtain accurate measurements.The aim of the study was to compare the average length value of the current upper and lower arches with that of a hypothetical nickel-titanium wire and the accuracy of the Bolton index measurement. In this retrospective study, plaster models of 138 adolescent Italian patients, provided by the Leone company of orthodontics and implantology in Sesto Fiorentino, were scanned using the 3Shape D800 scanner, which is equipped with a three-axis movement system allows tilting, rotation and movement of the models, making it possible to decipher all the anatomical details of the scanned model. Subsequently, the 138 dental casts were analysed using the Ortho3Shape software. Using the Ortho3Shape software, it was possible to measure the actual and ideal lengths of the lower arches and, for the Bolton analysis, the values of the anterior and total Bolton coefficients. By comparing the values obtained with those of the study by A. Anand Kumar et al. using CBCT and plaster casts, the reliability of the measurements obtained with such CAD/CAM orthodontic software was evaluated. Considering the validity of digital measurements demonstrated by the studies and systematic reviews in the literature, it can be stated that CAD/CAM digital models can be a viable alternative to plaster models in the coming years, as they can facilitate model preservation and retrieval. For future studies and research, it would be preferable to use intra-oral scanners (IOS) in order to ensure greater accuracy, requiring only one step and ensuring a better outcome for the patient.

Keywords: digital models; Bolton index; orthodontics CAD Software; extra-oral scanner

1. Introduction

Thanks to the great development of digital technology, through CAD (Computer - Aided Design) and CAM (Computer - Aided Manufacturing) systems, it has been possible to observe an important simplification of diagnosis and an improvement in the planning and execution of orthodontic treatment.

There are three pillars supporting CAD/CAM technology: the first is the acquisition of digital images of patients' dental arches patients' dental arches, the second is the visualisation and manipulation of these images in specific software, and finally the 3D printing files, whether of the devices designed or the models in which the devices will be manufactured [1].

Digital models could be used in decision-making and treatment planning, as there are many studies in the literature that support the validity of the measurements of digital models of the dental arch, the accuracy of the measurements of these models and the measurements of the anterior and total coefficients of the Bolton analysis being confirmed [2,3,4,5].

The Bolton analysis is useful for evaluating this aspect in the search for possible disproportions between the arches. In fact, this analysis is carried out by means of a calculation developed by Wayne Bolton in 1958, from which the Bolton index can be derived, which numerically expresses the ideal ratio between the mesio-distal diameters of the teeth of the upper arch compared to those of the lower arch, of which the mesio-distal diameters, at the contact points, of all the elements from the central incisors to the first molar must first be calculated.

As demonstrated in the literature, the rotational and translational movements of teeth can be analysed and reproduced with great precision using digital configurations and, in more complex orthodontic treatments, a preliminary virtual plan has the potential to allow a significant reduction in errors with a greater probability of predicting the outcome

In addition, digital technologies and artificial intelligence may allow greater opportunities for such planning, as they can be applied in the early stages of the clinical examination to develop a simultaneous virtual plan of all stages of treatment [6,7].

Recently, it has been shown that 3D printing can be a method to digitally design and then produce customisable clear aligners with greater precision as an alternative to conventional orthodontic appliances, while also offering greater fit and effectiveness [8].

The aim of the study, using an extra oral scanner and the Ortho3Shape software, was to compare the mean value of the length of the current upper and lower arches with that of a hypothetical nickel titanium wire and the accuracy of the measurement of the anterior and total coefficient of the Bolton index.

2. Materials and Methods

In the present study, in which all operations were performed by the same operator, data from the 138 selected dental casts were measured using the Ortho3Shape software. The mean value of the current upper and lower arches were compared with hypothetical nickel titanium orthodontic wire.

2.1. Dental casts selection

The inclusion criteria were:

- - Caucasian ethnicity.
- - Permanent dentition.
- - Class I and absence of severe malocclusions.
- - Absence of extractions or extensive reconstructions.
- - Absence of trauma and maxillo-facial surgery.
- - Absence of previous mobile and fixed orthodontic treatment.
- - Plaster models correctly scanned in 3D using Ortho3shape software.

The exclusion criteria were:

- - Presence of deciduous dental elements.
- - Abnormalities of eruption or formation of dental elements.
- - Rotated dental elements.
- - Agenesis of canine and central incisors.
- - Edentulous posterior dental elements.
- - Oligontia.

2.2. Procedures

In the present study, all operations were carried out by the same operator, the values taken into consideration (maximum, minimum, mean) from the dental casts selected, were calculated by using the Ortho3Shape software for the different measurements analysed: current length and of a hypothetical nickel-titanium orthodontic wire, the anterior and total Bolton coefficient.

For the analysis of the Bolton index, the lengths of the six anterior teeth of the upper arch and the six anterior teeth of the lower arch were measured (both lengths measured by summing the mesiodistal diameter of each of the dental elements from canine to canine). In order to measure the total coefficient, the lengths of the twelve maxillary and twelve mandibular teeth (both lengths measured by adding up the mesiodistal diameter of each of the dental elements from molar to molar) were measured.

To confirm the accuracy of the measurements of the Bolton indices of the anterior and total coefficients, the mean value of both values, calculated in the present study, were compared with those found in the study by A. Anand Kumar et al. and then both studies are compared with the student t-test [4].

The parameters used were:

- - *Bolton analysis:* this analysis consists of the calculation developed by Wayne Bolton, from which the Bolton index is obtained, which numerically expresses the ideal ratio between the mesio-distal diameters of the teeth of the upper arch in relation to those of the lower arch.
- - *Anterior Bolton coefficient:* ratio between the mesio-distal widths of the 6 mandibular anterior teeth and the mesio-distal widths of the 6 maxillary anterior teeth.
- - *Total Bolton coefficient:* ratio between the mesio-distal widths of the 12 mandibular teeth and the mesio-distal widths of the 12 maxillary teeth, from the contralateral first permanent molar to the contralateral first permanent molar.

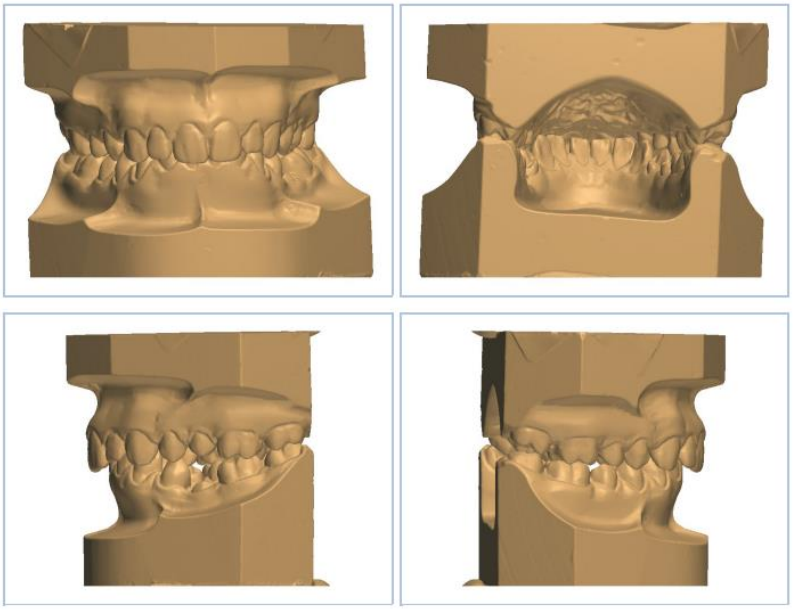

Figure 1. Digitally reproducedd image of a plaster model of a patient with an occlusion in the maximum. intercuspation position, frontal, back, left and right lateral vision can be observed.

2.3. Statistical analysis

Each models was evaluated twice, with an interval of 2 weeks, by the same operator. Intraobserver variabilità was caluclated by using Cohen's Kappa coeffficient. The coefficient obtained ranged between 0.9 and 0.97, that we assessed statistically significant.

The mean value were measured and Student's T test was adopted, the level of signifacance was set at $P < 0.05$.

The statistical analysis was performer with the SPSS (Statistical Package for Social Sciences, Chigago, USA) 22.0 program.

The mean value of the anterior and total Bolton coefficients in the present study were calculated and then compared with those in the study by A. Anand Kumar et al. (using CBCT and plaster casts) in order to assess the compatibility of the measurements and values obtained [9].

Subsequently, both studies were compared with the student t-test, in order to compare the mean value of the present study with that of study A. Anand Kumar et al. considering $p < 0.05$ as the cut-off value for a significant difference [9].

The study by A. Anand Kumar et al. included a sample of 50 adults all over the age of 18, with similar inclusion criteria as in our study:

- - Full permanent dentition from first molar to first molar in both upper and lower arch.
- - The participant does not have to undergo orthodontic treatment.
- - No severe crowding in the dentition [9].

3. Results

The results of the values examined in this study have been listed below in several tables, the average length of the current lower and upper arches and the corresponding hypothetical orthodontic nickel-titanium wires, the anterior and total Bolton coefficient.

Next, the mean value of the anterior and total coefficients of the Bolton analysis in the present study were compared with those calculated in the study by A. Anand Kumar et al. by CBCT and plaster casts, and finally these studies are compared by means of the student t-test [9].

3.1. Digital model arch analysis

Upper Arch Analysis	Hypothetical nickel titanium orthodontic wire upper arch lenght (mm)	Current upper arch length (mm)
Maximum Value	124.33	108.07
Minimum Value	80.03	66.47
Mean Value	103.79	92.13

Table 1.

Current length and of a hypothetical nickel-titanium orthodontic wire of the upper arch: the mean value calculated in the present study for the current length of the upper arch was 92.13 mm, while the mean value calculated for the hypothetical length of a nickel-titanium orthodontic wire of the upper arch was 103.79 [**Table 1**].

Consequently, it was possible to conclude that the mean value of the hypothetical length of a nickel-titanium orthodontic wire of the lower arch was 11.66 mm longer than that calculated for the current length of the upper arch.

Lower Arch Analysis	Hypothetical nickel titanium orthodontic wire lower arch lenght (mm)	Current lower arch length (mm)
Maximum Value	109.91	107.63
Minimum Value	75.32	68.47
Mean Value	94.71	88.26

Table 2.

Current length and of a hypothetical nickel-titanium orthodontic wire of the lower arch: the mean value calculated in the present study for the current length of the upper arch was 88.26 mm, while

the mean value calculated for the hypothetical length of a nickel-titanium orthodontic wire of the upper arch was 94.71 mm [Table 2].

Consequently, it was possible to conclude that the mean value of the hypothetical length of a nickel-titanium orthodontic wire of the lower arch was 6.45 mm longer than that calculated for the current length of the lower arch.

3.2. Bolton analysis digital models

Bolton Analysis: Anterior Coefficient	Sum 6 maxillary teeth (mm)	Sum 6 mandibular teeth (mm)	Report
Maximum Value	45.54	35.69	1.16
Minimum Value	24.33	22.58	0.62
Mean Value	38.16	30.10	0.79

Table 3.

Bolton Analysis: Total Coefficient	Sum 12 maxillary teeth (mm)	Sum 12 mandibular teeth (mm)	Report
Maximum Value	89.25	88.78	1.21
Minimum Value	58.10	53.39	0.68
Mean Value	78.99	73.77	0.94

Table 4.

3.3. Comparison analysis Bolton present study and A. Anand Kumar et al. study [4]

Mean Value	A. Anand Kumar et al. study	Present study	*P* Value
Anterior coefficient	0.76	0.79	0.0028
Total coefficient	0.91	0.94	0.0009

Table 5.

- - *Anterior coefficient (Bolton)*: In the study by A. Anand Kumar et al., the mean value of the anterior Bolton coefficient of the 50 subjects examined was 0.76 for both CBCT and plaster model measurements, and was compatible with that calculated in our study, which was 0.79 [9] [Table 5].
- - *Total coefficient (Bolton):* In the study by A. Anand Kumar et al., the mean value of the total Bolton coefficient of the 50 subjects examined was 0.91 for both CBCT and plaster model measurements, and was compatible with that calculated in our study, which was 0.94 [9] [Table 5].

3.3. Comparison by student t-test of the anterior and total Bolton coefficients of the two studies

- - *Student t-test*: following the test, the value for the anterior coefficient was found to be $P = 0.0028$ and for the total coefficient was found to be $P = 0.0009$ both indicating a significant difference.
- The differences found in Student's t-test are due to the different population size of the two studies compared: in the present study, 138 dental casts were examined, whereas in the study by A. Anand Kumar et al. the total number of patients examined was 50 [9] [Table 5].

4. Discussion

As has been done previously in other studies, dental models were digitised to obtain STL format files, the 'Standard Triangulation Language', using CAD/CAM technology, which allow the surface data of the dental arches to be saved on the computer in three-dimensional imaging [10,11,12].

STL files can allow clinicians to quickly obtain diagnostic information, arch width and perimeter, model discrepancies, Bolton discrepancy, overjet and overbite, as well as for the simulation of tooth movements [13].

Thus, the diagnostic configurations obtained through STL files can be used to evaluate better treatment strategies, increase their effectiveness and also allow, through digital planning, a better position of the fixed multibracket appliance on the teeth.

In fixed orthodontic therapy, brackets, bands and buccal tubes are used to transfer force and torque to the teeth, thus inducing tooth movement.

The accurate placement of orthodontic brackets is crucial, as deviations from the correct position of the brackets can lead to undesirable tooth movement.

Deviations from the correct bracket positions can lead to unwanted tooth movement, poor results and prolonged treatment times.

Computer-aided planning and production technology enables virtual planning of bracket positions and the of bracket positions, and bracket transfer splints can therefore be produced economically and easily and also digital processing can minimise positioning errors and increase treatment efficiency.

The accuracy of the final bracket position is defined as the deviation between the planned and actual bracket position [14,15,16].

The stereolithographic format can also be used in 3D printing software to be able to generate the necessary information for the production of 3D printed models, which can enable a more efficient workflow while saving time,

a set of errors for linear measurements considered clinically acceptable when replicating plaster models or printing digital models for diagnostic purposes have therefore been defined [17,18].

Again analysing the STL files of the present study, a comparison was made between the average value of the length of the ideal arch and the present arch.

The average value of the length of a hypothetical orthodontic nickel titanium wire of the ideal upper arch is 11.66 mm longer than the average value of the current upper arch length.

The average length value of a hypothetical ideal lower arch nickel titanium orthodontic wire is 6.45 mm longer than the average length value of the current lower arch.

A comparison analysis was then carried out between the present study and that of A. Anand Kumar et al.[9].

Apart from the result of the student's t-test (whose significant difference is due to the different sample sizes of the two studies being compared: 138 dental casts were examined in the present study, whereas 50 patients were examined in the other study), the mean value for the anterior and total coefficient of the Bolton index in the present study were compatible with those calculated in the other study [9].

Thus being able to confirm the reliability of the digitally taken measurements.

Consequently, the measurements that were made in the present retrospective study, both for the ideal and current upper and lower arch lengths, and for the anterior and total Bolton coefficients of the 138 dental casts examined, are useful to be able to establish the standard of such measurements in the Italian adolescent population.

The limitation of the present study is the double step for model reproduction, the first being the reproduction by plaster casts of the dental arches (scanned later) and the second by measuring the digital models using Ortho3Shape software.

5. Conclusions

The present study confirmed what has already been demonstrated in the scientific literature, that digital orthodontics and the reproduction of 3D digital models can contribute to the simplification of diagnosis and treatment planning in Orthodontics.

In the present study, the mean value of the anterior coefficients of the Bolton index was compatible with those of the study by A. Anand Kumar et al. confirming the reliability of digital measurements [9].

In the future, it would be preferable for studies and research to be conducted with the aid of intra-oral scanners (IOS) to ensure greater accuracy, requiring only one step and ensuring a better result for the patient.

6. Full presentation of all results

Upper Arch Analysis	Current upper arch length (mm)	Hypothetical nichel titanium orthodontic wire lower arch lenght (mm)
Patient 1	94,70	102,36
Patient 2	94,50	108,85
Patient 3	94,44	101,37
Patient 4	81,62	97,00
Patient 5	95,72	108,36
Patient 6	90,33	100,29
Patient 7	79,86	88,12
Patient 8	89,67	108,06
Patient 9	78,74	99,55
Patient 10	83,76	92,20
Patient 11	91,00	110,58
Patient 12	86,58	110,04
Patient 13	92,59	101,63
Patient 14	92,37	99,90
Patient 15	90,30	109,69
Patient 16	82,01	108,37
Patient 17	93,87	111,27
Patient 18	101,64	114,35
Patient 19	88,62	95,76
Patient 20	80,47	96,34
Patient 21	86,98	105,62
Patient 22	86,23	94,75
Patient 23	83,54	89,70
Patient 24	102,56	111,30
Patient 25	91,37	94,42
Patient 26	104,08	115,41
Patient 27	106,23	110,76
Patient 28	98,82	109,05
Patient 29	81,83	84,01
Patient 30	101,04	107,49
Patient 31	92,41	97,13
Patient 32	89,72	105,47
Patient 33	83,72	98,82
Patient 34	91,70	104,02
Patient 35	94,56	104,93
Patient 36	92,10	107,76
Patient 37	89,59	103,34
Patient 38	72,29	80,03
Patient 39	94,31	106,65
Patient 40	97,73	109,58
Patient 41	66,47	81,03
Patient 42	88,89	105,33
Patient 43	89,50	108,16
Patient 44	88,84	104,82

Patient 45	104,13	114,82
Patient 46	94,84	104,13
Patient 47	94,55	105,17
Patient 48	83,18	91,92
Patient 49	99,83	111,57
Patient 50	81,87	96,40
Patient 51	86,87	94,73
Patient 52	95,57	109,20
Patient 53	78,22	81,32
Patient 54	80,31	88,51
Patient 55	94,72	106,17
Patient 56	101,66	112,43
Patient 57	98,68	107,85
Patient 58	93,59	106,49
Patient 59	75,14	98,14
Patient 60	105,13	110,52
Patient 61	98,93	114,18
Patient 62	93,49	108,29
Patient 63	88,48	112,58
Patient 64	100,83	106,87
Patient 65	99,57	109,59
Patient 66	93,37	107,73
Patient 67	93,27	103,72
Patient 68	93,37	97,27
Patient 69	84,75	96,49
Patient 70	94,21	109,93
Patient 71	94,76	111,29
Patient 72	96,07	107,55
Patient 73	91,42	98,41
Patient 74	75,93	98,57
Patient 75	92,49	102,35
Patient 76	100,02	113,14
Patient 77	81,98	102,29
Patient 78	98,58	108,87
Patient 79	89,80	103,67
Patient 80	90,66	106,21
Patient 81	98,43	109,06
Patient 82	81,87	96,40
Patient 83	83,59	93,65
Patient 84	86,54	88,03
Patient 85	95,62	113,91
Patient 86	82,61	94,96
Patient 87	92,62	104,29
Patient 88	95,11	108,58
Patient 89	87,93	103,75
Patient 90	95,92	115,54
Patient 91	97,56	114,93
Patient 92	91,05	105,26
Patient 93	89,65	104,38
Patient 94	90,31	100,07
Patient 95	99,80	108,69

Patient 96	99,25	107,74
Patient 97	99,65	108,51
Patient 98	93,23	106,62
Patient 99	98,74	107,73
Patient 100	103,20	114,91
Patient 101	83,50	98,43
Patient 102	77,34	91,35
Patient 103	90,42	100,16
Patient 104	107,28	124,33
Patient 105	76,72	82,74
Patient 106	95,59	105,94
Patient 107	89,20	96,43
Patient 108	74,33	98,75
Patient 109	90,46	103,82
Patient 110	81,16	91,02
Patient 111	97,46	114,01
Patient 112	105,58	113,23
Patient 113	90,71	100,67
Patient 114	103,88	109,00
Patient 115	81,19	89,56
Patient 116	92,63	104,66
Patient 117	101,73	105,60
Patient 118	103,52	112,50
Patient 119	108,07	116,11
Patient 120	83,94	89,74
Patient 121	97,23	108,51
Patient 122	83,76	91,38
Patient 123	98,95	107,48
Patient 124	104,91	109,86
Patient 125	94,60	107,47
Patient 126	105,49	117,68
Patient 127	101,20	109,80
Patient 128	94,43	100,00
Patient 129	85,01	106,50
Patient 130	97,13	104,90
Patient 131	85,04	91,41
Patient 132	105,15	113,90
Patient 133	106,77	105,89
Patient 134	96,75	106,45
Patient 135	106,53	112,55
Patient 136	96,22	103,69
Patient 137	94,04	106,94
Patient 138	85,78	101,97
Maximum value	108,07	124,33
Minimum value	66,47	80,03
Mean value	92,13	103,79

Lower Arch Analysis	Current lower arch length (mm)	Hypothetical nichel titanium orthodontic wire lower arch lenght (mm)
Patient 1	68,47	85,41
Patient 2	90,68	94,25
Patient 3	73,30	88,62
Patient 4	84,00	97,62
Patient 5	78,06	95,87
Patient 6	89,25	93,99
Patient 7	81,05	89,37
Patient 8	87,74	98,10
Patient 9	79,19	86,99
Patient 10	75,78	83,42
Patient 11	85,70	100,02
Patient 12	83,67	98,45
Patient 13	82,47	89,67
Patient 14	87,30	95,95
Patient 15	84,22	98,38
Patient 16	86,76	97,96
Patient 17	90,59	105,06
Patient 18	91,70	103,28
Patient 19	83,95	89,23
Patient 20	78,75	94,90
Patient 21	90,21	98,00
Patient 22	79,52	83,99
Patient 23	75,64	81,76
Patient 24	93,27	104,15
Patient 25	86,93	90,49
Patient 26	94,47	102,75
Patient 27	99,76	97,65
Patient 28	95,43	99,54
Patient 29	71,78	75,99
Patient 30	95,41	93,65
Patient 31	82,87	86,96
Patient 32	85,00	93,60
Patient 33	81,27	90,92
Patient 34	80,58	90,43
Patient 35	89,49	96,01
Patient 36	87,21	93,02
Patient 37	97,93	103,89
Patient 38	73,15	76,08
Patient 39	84,74	95,59
Patient 40	93,58	99,93
Patient 41	75,28	80,92
Patient 42	84,32	97,00
Patient 43	82,06	95,63
Patient 44	81,52	90,16
Patient 45	92,44	99,72
Patient 46	90,96	94,75
Patient 47	88,40	95,31
Patient 48	92,14	100,20
Patient 49	95,21	98,78

Patient 50	87,76	98,03
Patient 51	78,81	82,86
Patient 52	89,38	96,24
Patient 53	80,24	84,03
Patient 54	86,77	88,60
Patient 55	96,09	102,17
Patient 56	99,58	103,42
Patient 57	79,48	94,85
Patient 58	90,82	94,42
Patient 59	78,16	86,88
Patient 60	97,80	101,31
Patient 61	92,60	103,85
Patient 62	92,25	99,34
Patient 63	93,97	106,03
Patient 64	102,75	103,27
Patient 65	90,83	97,30
Patient 66	88,25	98,70
Patient 67	88,94	96,92
Patient 68	82,31	85,30
Patient 69	86,31	91,18
Patient 70	70,14	92,27
Patient 71	89,72	105,32
Patient 72	91,16	95,94
Patient 73	91,63	92,23
Patient 74	78,33	96,21
Patient 75	82,64	89,71
Patient 76	93,51	106,16
Patient 77	82,53	92,30
Patient 78	96,09	99,16
Patient 79	92,12	94,01
Patient 80	90,04	97,57
Patient 81	92,38	96,86
Patient 82	87,76	98,03
Patient 83	78,22	83,61
Patient 84	93,54	97,31
Patient 85	92,09	100,18
Patient 86	84,37	93,27
Patient 87	91,86	96,61
Patient 88	89,90	94,03
Patient 89	78,94	93,77
Patient 90	92,47	101,37
Patient 91	92,32	103,49
Patient 92	84,88	93,14
Patient 93	84,33	95,19
Patient 94	87,94	88,81
Patient 95	98,28	96,67
Patient 96	92,50	98,61
Patient 97	94,61	94,17
Patient 98	78,79	88,32
Patient 99	91,01	94,48
Patient 100	97,02	100,66

Patient 101	80,01	92,01
Patient 102	77,34	81,02
Patient 103	90,74	94,81
Patient 104	107,63	109,91
Patient 105	78,90	83,85
Patient 106	94,60	98,87
Patient 107	97,58	98,79
Patient 108	86,93	90,41
Patient 109	94,15	96,98
Patient 110	77,96	88,47
Patient 111	93,85	99,43
Patient 112	93,53	102,21
Patient 113	96,29	98,78
Patient 114	97,60	99,00
Patient 115	91,03	93,02
Patient 116	76,87	79,41
Patient 117	89,07	94,48
Patient 118	102,22	100,63
Patient 119	101,27	105,05
Patient 120	77,37	80,99
Patient 121	89,64	99,42
Patient 122	94,65	100,29
Patient 123	105,04	101,05
Patient 124	88,78	89,58
Patient 125	90,17	95,10
Patient 126	104,66	108,18
Patient 127	96,83	102,96
Patient 128	75,93	77,34
Patient 129	85,97	87,94
Patient 130	82,99	75,32
Patient 131	90,08	91,73
Patient 132	102,15	99,97
Patient 133	99,64	93,74
Patient 134	84,95	94,45
Patient 135	103,16	102,17
Patient 136	87,26	96,62
Patient 137	94,32	94,63
Patient 138	90,99	93,64
Maximum value	107,63	109,91
Minimum value	68,47	75,32
Mean value	88,26	94,71

Bolton Analysis: Anterior Coefficient	Sum 6 maxillary teeth (mm)	Sum 6 mandibular teeth (mm)	Report
Patient 1	38,60	28,28	0,73
Patient 2	39,88	30,66	0,77
Patient 3	38,99	31,08	0,80
Patient 4	33,81	26,18	0,77
Patient 5	39,52	28,88	0,73

Patient 6	33,60	29,78	0,86
Patient 7	35,13	25,26	0,72
Patient 8	37,57	28,00	0,75
Patient 9	32,47	25,31	0,78
Patient 10	36,03	27,78	0,77
Patient 11	33,99	26,83	0,79
Patient 12	33,99	26,73	0,79
Patient 13	34,33	26,19	0,76
Patient 14	40,00	29,74	0,74
Patient 15	35,88	27,72	0,77
Patient 16	24,33	28,22	1,16
Patient 17	37,34	28,85	0,77
Patient 18	38,35	30,71	0,80
Patient 19	34,72	27,88	0,80
Patient 20	35,64	27,2	0,76
Patient 21	32,36	28,05	0,87
Patient 22	36,88	29,54	0,80
Patient 23	37,22	26,55	0,71
Patient 24	42,70	33,61	0,79
Patient 25	37,87	27,92	0,74
Patient 26	45,54	33,35	0,73
Patient 27	44,95	35,38	0,79
Patient 28	36,94	29,24	0,79
Patient 29	38,23	28,49	0,75
Patient 30	43,01	31,35	0,73
Patient 31	36,50	24,59	0,67
Patient 32	34,82	27,29	0,78
Patient 33	35,99	30,54	0,85
Patient 34	36,34	22,58	0,62
Patient 35	36,12	28,24	0,78
Patient 36	34,41	28,22	0,82
Patient 37	39,17	29,64	0,76
Patient 38	34,33	30,47	0,89
Patient 39	35,08	27,09	0,77
Patient 40	36,49	28,13	0,77
Patient 41	36,36	29,89	0,82
Patient 42	35,24	27,13	0,77
Patient 43	34,58	26,88	0,78
Patient 44	32,42	24,71	0,76
Patient 45	40,75	30,62	0,75
Patient 46	40,19	32,15	0,80
Patient 47	39,15	29,34	0,75
Patient 48	40,45	31,58	0,78
Patient 49	39,93	30,40	0,76
Patient 50	40,04	33,43	0,83
Patient 51	38,08	27,24	0,72
Patient 52	37,37	29,95	0,80
Patient 53	36,78	27,96	0,76
Patient 54	37,86	28,33	0,75
Patient 55	37,27	31,89	0,86
Patient 56	41,98	33,34	0,79

Patient 57	38,40	30,96	0,81
Patient 58	38,55	33,72	0,87
Patient 59	29,69	27,88	0,94
Patient 60	41,31	30,85	0,75
Patient 61	42,65	32,01	0,75
Patient 62	36,76	27,52	0,75
Patient 63	40,38	32,29	0,80
Patient 64	41,88	34,12	0,81
Patient 65	38,80	28,92	0,75
Patient 66	35,30	28,41	0,80
Patient 67	37,32	29,41	0,79
Patient 68	36,74	26,87	0,73
Patient 69	36,23	30,24	0,83
Patient 70	38,52	29,30	0,76
Patient 71	36,27	30,55	0,84
Patient 72	36,83	28,73	0,78
Patient 73	36,68	28,44	0,78
Patient 74	36,87	29,01	0,79
Patient 75	35,11	27,12	0,77
Patient 76	39,51	32,26	0,82
Patient 77	33,75	26,33	0,79
Patient 78	39,62	30,26	0,76
Patient 79	33,75	30,08	0,89
Patient 80	36,37	29,33	0,81
Patient 81	38,69	29,71	0,77
Patient 82	44,04	33,43	0,83
Patient 83	39,19	31,40	0,80
Patient 84	39,71	31,86	0,80
Patient 85	40,01	31,51	0,79
Patient 86	34,63	28,44	0,82
Patient 87	39,02	31,82	0,82
Patient 88	37,22	30,48	0,82
Patient 89	36,43	26,99	0,74
Patient 90	38,97	30,85	0,79
Patient 91	42,33	30,00	0,71
Patient 92	34,38	28,21	0,82
Patient 93	34,77	27,51	0,79
Patient 94	34,24	29,18	0,85
Patient 95	38,60	30,32	0,79
Patient 96	38,73	30,84	0,80
Patient 97	39,93	32,52	0,81
Patient 98	41,81	33,98	0,81
Patient 99	41,55	30,92	0,74
Patient 100	42,06	31,52	0,75
Patient 101	30,15	28,04	0,93
Patient 102	31,87	30,54	0,96
Patient 103	34,20	28,44	0,83
Patient 104	44,46	35,12	0,79
Patient 105	34,02	28,32	0,83
Patient 106	39,12	30,72	0,79
Patient 107	45,32	32,24	0,71

Patient 108	37,38	29,10	0,78
Patient 109	36,08	32,02	0,89
Patient 110	37,49	31,00	0,83
Patient 111	43,61	31,03	0,71
Patient 112	44,64	34,26	0,77
Patient 113	40,43	32,80	0,81
Patient 114	41,66	31,44	0,75
Patient 115	36,54	30,32	0,83
Patient 116	42,50	33,02	0,78
Patient 117	40,72	33,38	0,82
Patient 118	43,55	34,79	0,80
Patient 119	44,49	32,76	0,74
Patient 120	36,88	27,11	0,74
Patient 121	41,03	30,03	0,73
Patient 122	38,39	28,84	0,75
Patient 123	40,35	33,91	0,84
Patient 124	42,67	33,54	0,79
Patient 125	39,79	30,13	0,76
Patient 126	44,65	35,69	0,80
Patient 127	38,72	33,58	0,87
Patient 128	45,16	31,93	0,71
Patient 129	27,94	30,96	1,11
Patient 130	41,78	34,55	0,83
Patient 131	40,47	32,08	0,79
Patient 132	43,94	35,36	0,80
Patient 133	43,29	35,40	0,82
Patient 134	40,02	29,72	0,74
Patient 135	43,18	34,79	0,81
Patient 136	38,47	30,82	0,80
Patient 137	40,94	33,51	0,82
Patient 138	38,51	32,16	0,83
Maximum value	45,54	35,69	1,16
Minimum value	24,33	22,58	0,62
Mean value	38,16	30,12	0,79

Bolton Analysis: Total Coefficient	Sum 12 maxillary teeth (mm)	Sum 12 mandibular teeth (mm)	Report
Patient 1	79,71	60,18	0,75
Patient 2	79,46	74,27	0,93
Patient 3	79,56	60,33	0,76
Patient 4	73,23	69,17	0,94
Patient 5	80,14	62,02	0,77
Patient 6	74,55	71,79	0,96
Patient 7	76,63	66,54	0,90
Patient 8	70,15	70,37	1,00
Patient 9	65,69	63,29	0,96
Patient 10	83,76	75,78	0,90
Patient 11	71,76	68,57	0,96
Patient 12	71,51	66,77	0,93

Patient 13	72,83	67,41	0,93
Patient 14	78,07	71,93	0,92
Patient 15	75,28	67,96	0,90
Patient 16	67,79	69,77	1,03
Patient 17	78,43	72,83	0,93
Patient 18	83,91	74,73	0,89
Patient 19	74,07	67,44	0,91
Patient 20	73,92	63,64	0,86
Patient 21	73,58	72,44	0,98
Patient 22	86,23	79,52	0,92
Patient 23	83,54	75,64	0,91
Patient 24	87,13	77,42	0,89
Patient 25	75,66	69,59	0,92
Patient 26	88,02	78,2	0,89
Patient 27	88,40	84,63	0,96
Patient 28	78,85	75,50	0,96
Patient 29	81,83	71,78	0,88
Patient 30	83,93	76,22	0,91
Patient 31	75,25	66,12	0,88
Patient 32	74,96	69,05	0,92
Patient 33	75,92	73,60	0,97
Patient 34	76,33	63,90	0,84
Patient 35	79,47	73,84	0,93
Patient 36	73,46	70,17	0,96
Patient 37	82,88	77,39	0,93
Patient 38	72,29	73,15	1,01
Patient 39	76,82	67,92	0,88
Patient 40	78,20	75,53	0,97
Patient 41	66,47	75,28	1,13
Patient 42	71,67	66,22	0,92
Patient 43	73,97	66,47	0,90
Patient 44	72,44	65,45	0,90
Patient 45	85,10	74,81	0,88
Patient 46	77,97	74,75	0,96
Patient 47	77,33	70,72	0,91
Patient 48	83,18	78,16	0,94
Patient 49	85,19	76,66	0,90
Patient 50	81,87	79,99	0,98
Patient 51	79,64	70,23	0,88
Patient 52	80,13	72,62	0,91
Patient 53	78,22	72,10	0,92
Patient 54	80,31	76,87	0,96
Patient 55	78,15	76,65	0,98
Patient 56	83,80	80,25	0,96
Patient 57	81,18	79,48	0,98
Patient 58	77,03	74,29	0,96
Patient 59	75,14	78,16	1,04
Patient 60	85,68	80,50	0,94
Patient 61	82,58	76,18	0,92
Patient 62	76,94	74,10	0,96
Patient 63	80,99	78,76	0,97
Patient 64	87,42	85,77	0,98
Patient 65	81,57	73,55	0,90
Patient 66	75,95	71,09	0,94
Patient 67	78,47	71,89	0,92
Patient 68	76,55	69,20	0,90

Patient 69	71,97	71,12	0,99
Patient 70	78,18	53,39	0,68
Patient 71	76,22	71,99	0,94
Patient 72	78,24	72,60	0,93
Patient 73	75,69	70,67	0,93
Patient 74	59,30	62,59	1,06
Patient 75	75,49	65,94	0,87
Patient 76	84,03	76,50	0,91
Patient 77	68,61	66,22	0,97
Patient 78	82,27	77,23	0,94
Patient 79	73,10	74,18	1,01
Patient 80	74,58	72,24	0,97
Patient 81	80,43	74,68	0,93
Patient 82	81,87	79,99	0,98
Patient 83	83,59	78,22	0,94
Patient 84	86,54	76,28	0,88
Patient 85	79,63	75,18	0,94
Patient 86	74,92	68,35	0,91
Patient 87	78,50	74,70	0,95
Patient 88	79,18	72,66	0,92
Patient 89	72,44	64,74	0,89
Patient 90	80,33	76,36	0,95
Patient 91	82,71	75,55	0,91
Patient 92	76,64	69,24	0,90
Patient 93	73,39	67,12	0,91
Patient 94	74,48	70,11	0,94
Patient 95	82,51	78,94	0,96
Patient 96	81,43	76,89	0,94
Patient 97	81,95	76,02	0,93
Patient 98	79,82	70,85	0,89
Patient 99	83,42	73,96	0,89
Patient 100	85,51	77,54	0,91
Patient 101	68,02	66,64	0,98
Patient 102	77,34	77,34	1,00
Patient 103	75,97	72,11	0,95
Patient 104	89,25	84,89	0,95
Patient 105	76,72	72,10	0,94
Patient 106	80,43	76,22	0,95
Patient 107	89,20	78,27	0,88
Patient 108	58,10	70,39	1,21
Patient 109	74,51	76,06	1,02
Patient 110	74,26	62,71	0,84
Patient 111	84,33	75,43	0,89
Patient 112	85,75	76,45	0,89
Patient 113	81,74	78,90	0,97
Patient 114	85,86	78,61	0,92
Patient 115	74,33	73,96	1,00
Patient 116	82,26	76,87	0,93
Patient 117	86,05	80,28	0,93
Patient 118	87,69	83,21	0,95
Patient 119	88,77	81,23	0,92
Patient 120	83,94	77,37	0,92
Patient 121	81,57	71,91	0,88
Patient 122	83,76	78,54	0,94
Patient 123	82,46	80,93	0,98
Patient 124	86,55	88,78	1,03

Patient 125	77,75	72,97	0,94
Patient 126	89,17	84,58	0,95
Patient 127	74,84	79,81	1,07
Patient 128	88,77	75,93	0,86
Patient 129	69,74	76,45	1,10
Patient 130	81,50	82,99	1,02
Patient 131	85,04	85,37	1,00
Patient 132	86,49	83,02	0,96
Patient 133	87,06	81,67	0,94
Patient 134	81,12	69,22	0,85
Patient 135	89,25	85,09	0,95
Patient 136	80,35	73,51	0,91
Patient 137	80,16	76,82	0,96
Patient 138	74,83	74,35	0,99
Maximum value	89,25	88,78	1,21
Minimum value	58,10	53,39	0,68
Mean value	78,99	73,77	0,94

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