DENTAL WINGS CAD/CAM SYSTEM PRECISION: AN INTERNAL AND MARGINAL FIT SPERIMENTAL ANALISYS

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SUMMARY

Dental Wings CAD/CAM system precision: an internal and marginal fit sperimental analisys.

Statement of problem. The CAD-CAM technology has been developed to design and manufacture prosthetic structures with constant quality characteristics; in fact procedures are codified, manageable and repeatable.

Purpose. The purpose of this in vitro study is to evaluate the internal and marginal gap of zirconia casts made with a new CAD-CAM systematic that use Dental Wings laser scanner and Yenamak milling machine.

Material and methods. 6 analogs of solid abutments of Straumann implants were used, fixed in plexiglass bases. The samples were scanned by Dental Wings laser; the file obtained by scanning of each probe was sent to the Yenamak D40 milling machine, then the casts were sintered in Protherm furnace. Then 6 samples were cemented with resin luting agent capsules (Relyx Unicem, 3M ESPE). The samples were incorporated in transparent epoxy resin. After resin hardening, the cylinders obtained were cut with a microtomes. These slices thus obtained were then polished with a Polisher sander with alumina dust decreasing grain. Each section was observed and photographed in reflected light with the aid of an optic microscope type, first at low magnification and then at higher magnification.

Results. The overall average fitting of copings on the abutments was 32,87 µ. No differences were found in marginal fit on buccal and lingual sides, it was easily predictable because of the standard form of the used stumps.

The recorded values for the marginal fit were lower than those of axial walls.

The accuracy of adaptation was always achieved within the limits of clinical acceptability.

Conclusions. Within the limitations of this study, the system evaluated represents a valuable alternative to conventional prosthetic rehabilitation techniques.

RIASSUNTO

Precisione della sistematica CAD/CAM Dental Wings: analisi sperimentale dell'adattamento interno e marginale.

Istruzione del problema. La tecnologia CAD-CAM è stata sviluppata con l'obiettivo di progettare e realizzare strutture protesiche con caratteristiche di qualità costanti; infatti, permette di utilizzare procedure codificate, protocollate, controllabili e soprattutto ripetibili.

Proposta. Scopo di questo lavoro in vitro è valutare la precisione marginale ed interna di cappette in zirconio realizzate mediante una nuova sistematica CAD-CAM che utilizza lo scanner laser della Dental Wings, abbinato al fresatore della Yenamak.

Materiale e metodi. Sono stati utilizzati 6 analoghi di monconi pieni degli impianti Straumann fissati all'interno di basette di plexiglass. Gli esemplari così costituiti sono stati sottoposti a lettura laser dello scanner Dental Wings; il file ottenuto dalla scansione di ciascun provino è stato inviato alla macchina fresatrice Yenamak D40, quindi i manufatti sono stati sinterizzati nel forno Protherm. I 6 provini sono stati quindi cementati con un cemento resinoso in capsule (Relyx Unicem, 3M espe). Si è passati alla successiva fase che prevedeva un inglobamento dei provini all'interno di resina epossidica trasparente. Ad indurimento completato della resina i cilindri così ottenuti sono stati tagliati con un microtomo sezionatore. Le sezioni sono state successivamente lucidate con una levigatrice con polveri di allumina a grana decrescente. Ogni sezione è stata osservata e fotografata a luce riflessa con l'ausilio di un microscopio ottico dapprima a piccolo ingrandimento e poi ad ingrandimenti maggiori

Risultati. La media complessiva di adattamento delle cappette sui monconi è stata di 32,87 µ. Non sono state riscontrate differenze di adattamento marginale sui versanti vestibolare e linguale, cosa che era facilmente prevedibile per via della forma standard dei monconi utilizzati. I valori registrati per l'adattamento marginale erano più bassi di quelli delle pareti assiali.

La precisione dell'adattamento raggiunta era comunque sempre nei limiti dell'accettabilità clinica.

Conclusioni. Con le limitazioni di questo studio, possiamo affermare che la sistematica valutata rappresenta una valida alternativa alle tradizionali tecniche protesiche riabilitative.

Key words: marginal fit, CAD-CAM, zirconia.

Parole chiave: adattamento marginale, CAD-CAM, zirconio.

Introduction

The desire to achieve excellent aesthetic results by fixed partial prosthesis on natural teeth and implants has led to a growth in demand and the subsequent use of the ceramic over the years (1-3) in anterior as well as posterior regions (4-6).
On the first attempt made by McLean in 1967 to use aluminum for the structure of fixed partial dentures, have been developed many types of ceramic restorations that use materials (lithium-disilicato oxide, alumina, zirconia) and techniques (slip-casting, investment casting, casting, CAD/CAM systems) (7).
CAD/CAM stands for Computer Aided Design / Computer Aided Manufacturing, thereby indicating that design and production phases are assisted by computer.
This technology dates back to the 60s, but only after 10 years it has been applied to the dental industry.
The Cerec was the first CAD/CAM system and it was designed at the University of Zurich in 1981th (8).
Since then, other CAD/CAM sistems has been developed as a result of improved performance of both computer and software applications.
The CAD/CAM technology has been developed to design and manufacture prosthetic structures with constant quality characteristics; in fact procedures are codified, manageable and repeatable.
Current laser and optical technologies allow to obtain reliable data, with increasingly sophisticated software and allow to perform precise and faithful milling paths.
The CAD/CAM technology allows the production of prosthetic structures using zirconium dioxide and aluminum oxide, as well as bio-titanium, cobalt chrome and synthetic materials as an alternative to traditional techniques.
Zirconium oxide, with its excellent strength and biocompatibility, known in implant orthopedic prosthesis (9), is the material of choice for prosthetic structures in the posterior regions. The accumulation of plaque on a ceramic restorations is comparable to that which occurs on a natural tooth. Moreover, unlike the elements with support in metal, ceramic restorations have a low thermal conductivity, thus eliminating the sensitivity to temperature changes and a better aesthetic.
But ceramic crowns must meet certain requirements for resistance to masticatory loads, marginal accuracy and color stability to ensure success (10-13).
Marginal accuracy is very important for all ceramic crowns long-term success (14-17) and researchers try to reduce the distance between the element and the dental restoration by many efforts (18).
A not perfect marginal closure makes tooth more susceptible to plaque accumulation, the occurrence of secondary caries and pulpits, and parodontal damages (19, 20).
Marginal openings of between 50 and 120 μ are considered clinically acceptable with regard to longevity (14-17).
The size of the gap may depend on the thickness of the dental cement layer. Many factors affecting this layer, such as preparation design, die spacer, seating force, marginal configuration and surface roughness have been studied (2).
American Dental Association (ADA) Specification No. 8 states that the luting cement film thickness for a crown restoration should be no more than 25 mm when using a Type I luting agent, or 40 mm with a Type II luting agent, but in the clinical practice is hard achieving this value (22).
Some authors have argued that a marginal opening

of ≤ 120 μ was clinically acceptable (14) and subsequent similar studies on all ceramic crown systems have reported mean marginal openings of approximately 155 μ with a range of 0 to 313 μ (23-45).
Today most dentists agree that marginal openings between 40 and 100 μ are clinically acceptable.
Several all ceramic crowns systems were analyzed with particular regard to marginal accuracy (45).
The aim of this study was to analyze by light microscopy the internal and external precision of zirconium copings manifactured by a DW - 5-140 Dental Wings laser scanning (Dental - Wings Inc., Montreal QC, Canada), information developing by software, a Yenamak D40 milling machine (Yena Makina San. Tic. Ltd. Sti., Y. Dudullu, Istanbul, Turkey) and a final sintering by furnace Protherm PLS 150 (Protherm).

Materials and methods

Most studies on marginal accuracy used extracted teeth or epoxy resin replicas of prepared teeth. In our study, however, to achieve a better standardization of all phases, 6 analogs of solid abutments of Straumann implants (Straumann, Basel, Switzerland) were used.
The samples were divided into 2 groups; each group consisted of 3 copies:
The first group consisted of 4.8 mm diameter, 4 mm height analog RN, with a 50° shoulder of 1.5 mm over the entire circumference and a taper of 3° for side (048.160, Straumann, Basel, Switzerland);
The second group consisted of 6.5 mm diameter, 4 mm height analog WN, with a 50° shoulder of 1.5 mm over the entire circumference and a taper of 3° for side (048.165, Straumann, Basel, Switzerland)
Then they were fixed by cyanoacrylate (Super-attak, Loctite) in plexiglass bases (Fig. 1).
The samples were numbered in buccal – palatal direction; then they were scanned by DW - 5 - 140 Dental Wings laser (Dental - Wings Inc., Montreal QC, Canada) and fixed on the spindle of the same machine (Fig. 2).
The digital model was obtained by 5-axis optical scanner with triangulation laser that can scan impressions and partial or complete models, with extractable or fixed elements; it is the only able to scan simultaneously 16 elments because of the large dimension plate, with stated accuracy of 0.02 μm in 1 min for item (Fig. 3).
The software can model virtually the substructures and the morphology of each single element of the rehabilitation with extensive checks on each connector too (Fig. 4).
The file obtained by scanning of each probe was sent to the Yenamak D40 milling machine (Yena Makina San. Tic. Ltd. Sti., Y. Dudullu, Istanbul, Turkey) (Fig. 5).
The machine is fully compatible with open systems 3D scanners that can generate file.stl by a CAM integrated system, and can work with different materials (Zirconia, PMMA, CrCo, Ti, Ceramics).
The milling block occurs on five axes of rotation and this allows best accuracy in framework manifacturing.
We used a 98 mm diameter and 16 mm thickness Copran presintered zirconium block.

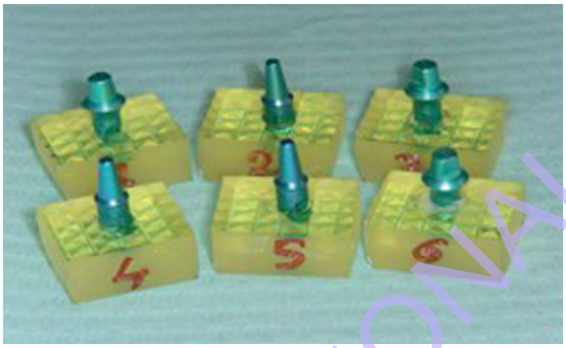

Figure 1
Analog fixed in plexiglass bases.

Figure 2
Scanner DW – 5 – 140 Dental Wings (Dental – Wings Inc., Montreal QC, Canada).

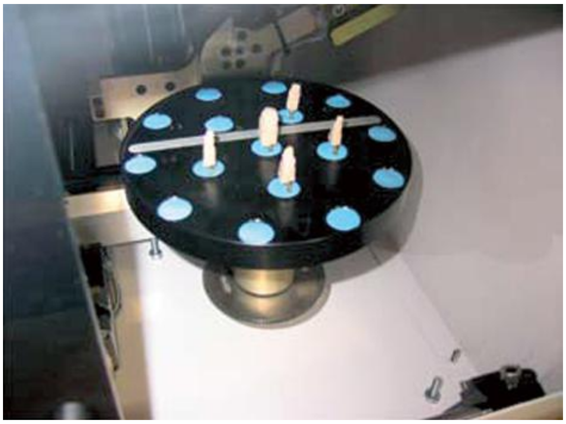

Figure 3
Scanning plate.

The casts were sintered in Protherm MOS - 150 furnace according to a thermal cycle of 11 h, reaching gradually the temperature of 1450°C and then coming back to room temperature gradually.
The casts were seated on models and the coupling accuracy was previously assessed (Figg. 6a-b).
Although guide-lines about luting technique zirconia crowns does not exist yet, the best results in terms of fracture resistance were obtained with resinous cement.
Then 6 samples were cemented with resin luting agent capsules (Relyx Unicem, 3M ESPE) (Fig. 7) to minimize all operator-dependent variables (exact proportions of the materials, technique and time of mixing, etc.) and obtain a standardization.
The cement was placed inside the casts and on the analogs top to achieve a more uniform cement distribution.

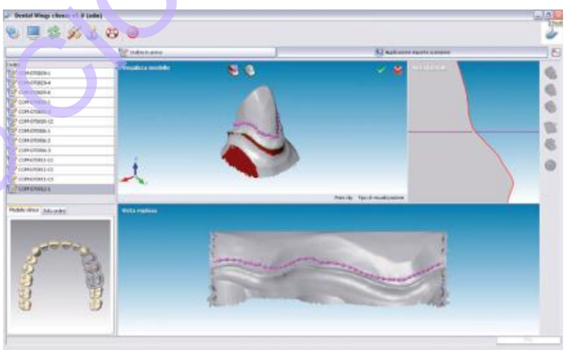

Figure 4
3D scanning and finish line detection.

Figure 5
Milling machine.

The casts were manually placed on the model and then subjected to a constant static load of 50N for 7min using a device that was developed and tested in previous studies by our school (Figg. 8 a, b, c).
After 7 min, cement excesses were removed.
The samples were incorporated in transparent epoxy resin (E227 Prochima) (Figg. 9 a, b).
After resin hardening (about 24h), the cylinders obtained were cut with a Buehler microtomes ISOMET Plus, polished and analyzed (Figg. 10 a, b).
These slices thus obtained were then polished with a Beuhler Metaserv Grinder Polisher sander with alumina dust decreasing grain (1 - 0.3 - 0.05 micron) (Fig. 11).
Each section was observed and photographed in reflected light with the aid of a Zeiss Axiophot microscope type, first at low magnification and then at higher magnification (Fig. 12).
Each sample was sectioned in buccal-lingual direction, obtaining 2 symmetrical half (mesial and distal) in order to obtain 2 recording areas for each sample.
For each section 5 values, were recorded.


Figure 6 a, b
Sintered coping accuracy examination.

The total amount of adaptation for each model was calculated as the average of the 10 values previously obtained.
Final value of the adaptation was calculated as the average of the values for each model.
All measurements were performed on the section picture using a known length notch, and each value at different magnifications was checked. The method used to measure the gap between model and cast is the following: (1000/magnification) X 10 = micrometer, where the magnification was obtained by considering the following comparative table (Tab. 1). Then the millimeters thus obtained were divided by the length of this notch as a reference on the images, in this way the value in micrometers was obtained. So with the millimetric notch the values of marginal gap and internal adaptation were measured and each of those were multiplied by its value obtained previously.

Results

Mean marginal gaps of the slices taken into consideration (Figs. 13, 14) after light microscope analysis:
Table 1 shows 5 average values of points taken into consideration of the two sections of each coping.
Table 2 lists the average values of each coping and was therefore evaluated the overall average fitting of copings on the abutments.

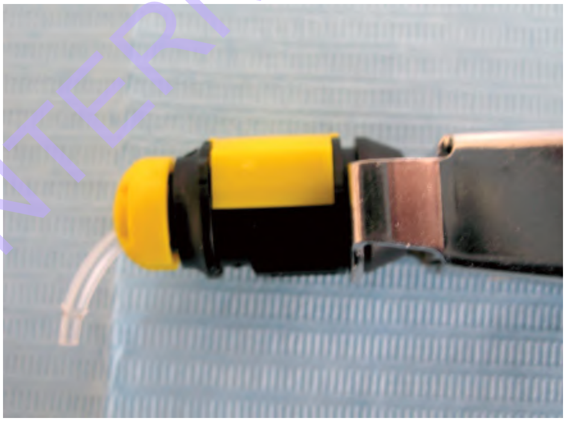

Figure 7
Resin cuting acent capsules.

Discussion and conclusion

The marginal accuracy is an important criterion for assessing the quality of a crown. Literature reviewed marginal adaptation of various structures in zirconium, but the data show a large variability of results depending on the used system (32, 50).
Generally, the assessment of marginal discrepancy depends on many factors, such as points of reference for measurement and the correct definition of marginal discrepancy (36, 51).
No differences were found in marginal fit on buccal and lingual sides; it was easily predictable because of the standard form of the used stumps.

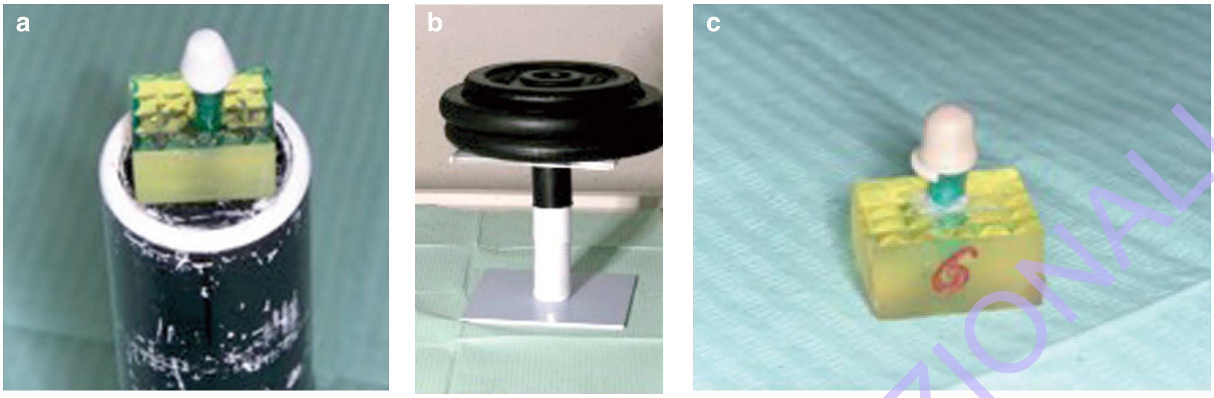

Figure 8 a, b, c
Sample placed on cementation devices (a); costant load (b); cemented coping (c).

Figure 9 a, b
Transparent epoxy resin (a) incorporated samples (b).

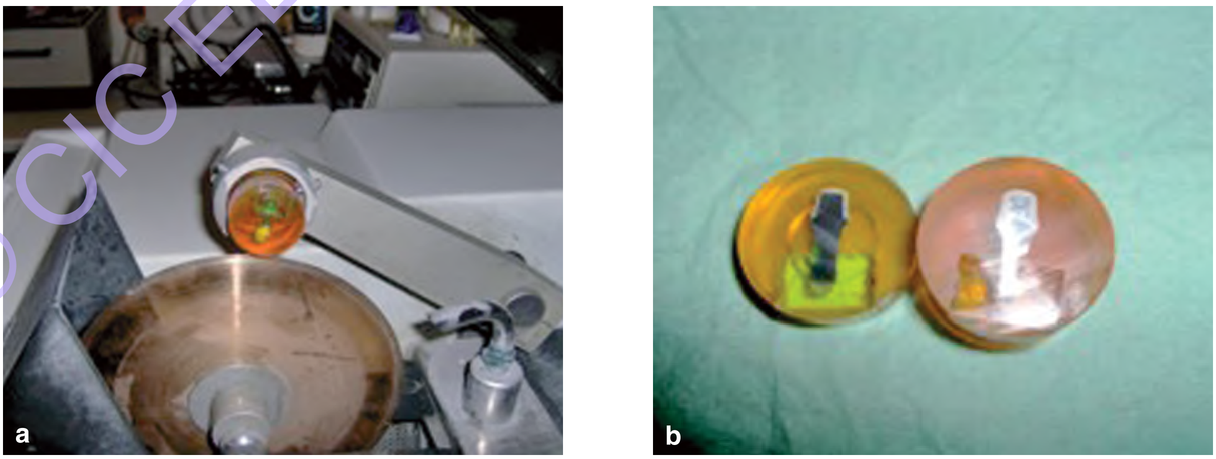

Figure 10 a, b
Buehler Isomet Plus Microtomes (a) e selectioned model (b).

Figure 11
Beuhler Metaserv Grinder Polisher sander.

Figure 12
Axiophot Zeiss microscope.

Table 1 - Conversion vawes.

Target	Enlarge
5x	50
10x	100
20x	200
50x	500

The recorded values for the marginal fit were lower than those of axial walls.
The achieved accuracy of adaptation was always within the limits of clinical acceptability.
The largest gaps were found at the occlusal level, where use of 1 mm diameter drill results in an offset, thereby a major milling of coping to compen-

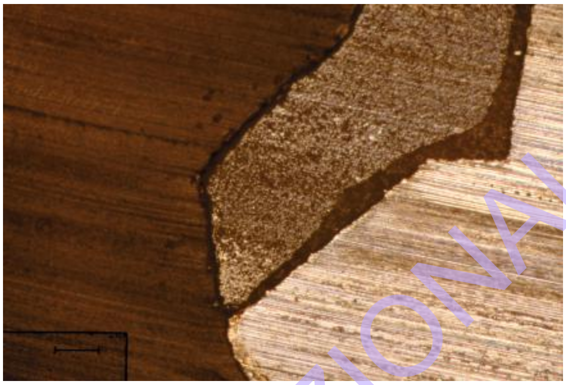

Figure 13
Coping n° 3: lingual marginal gap at 50x magnification.

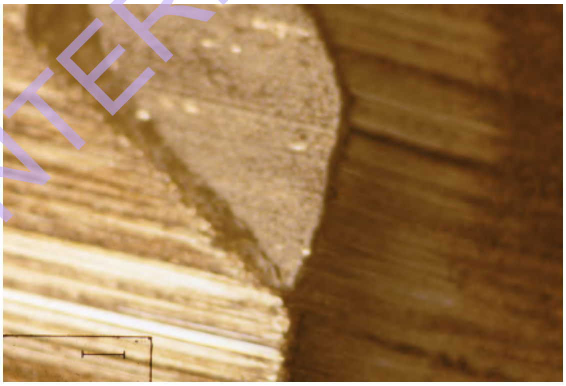

Figure 14
Coping n°4: vestibolar marginal gap at 100x magnification.

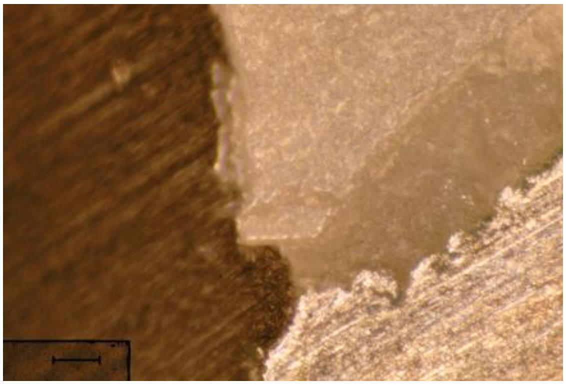

Figure 15
Coping n° 2: lingual marginal gap at 200x magnification.

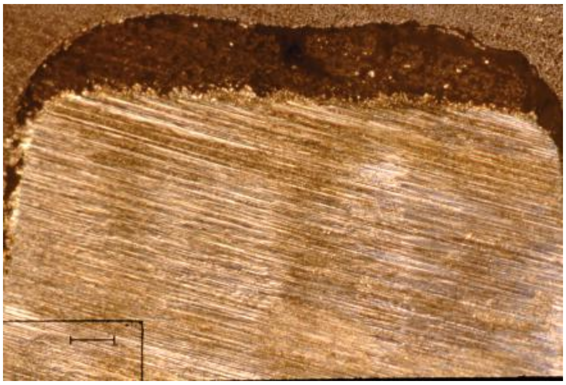

Figure 16
Coping n° 1: oclusal gap at 100x magnification.

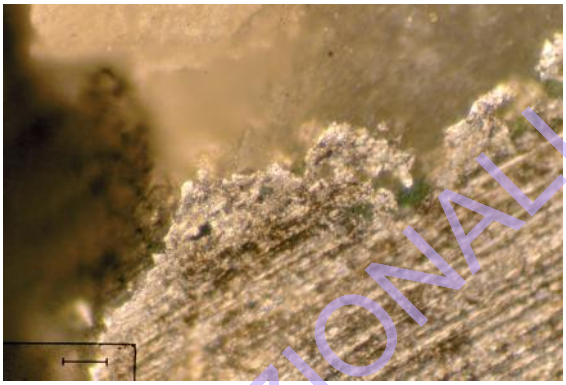

Figure 17
Coping n° 5: lingual marginal gap at 500x magnification.

sate for the presence of a smaller angle made by axial wall with occlusal surface.
Although in this study similar pre-formed were used to reach standardization, it becomes evident that the difference in morphology of the stumps examined and the different lines of marginal preparation must be in count in the next research.
Whereas of the results obtained from our research and according with numerous studies in the literature (5, 18, 46), the system evaluated represents a valuable alternative to conventional prosthetic rehabilitation techniques.

Table 3 - Average of 5 examined and total average.

Coping 1	23,45µ
Coping 2	36,25µ
Coping 3	30,92µ
Coping 4	37,73µ
Coping 5	42,43µ
Coping 6	26,45µ
Total Average	32,87µ

Table 2 - Average values of the gap of each examined point.

	Average marginal lingual gap	**Average marginal buccal gap**	**Average axial lingual gap**	**Average axial buccal gap**	**Average occlusal gap**
Coping 1	23,42µ	23,18µ	23,82µ	23,42µ	53,42µ
Coping 2	32,12µ	32,33µ	32,48µ	32,21µ	52,12µ
Coping 3	24,71µ	24,62µ	25,62µ	24,97µ	54,71µ
Coping 4	33,64µ	33,37µ	34,17µ	33,82µ	53,64µ
Coping 5	26,17µ	26,68µ	28,25µ	28,53µ	56,17µ
Coping 6	35,45µ	35,58µ	37,45µ	38,22µ	65,45µ
Total Average	29,25µ	29,29µ	30,30µ	30,19µ	55,92µ

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