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CAD/CAM (Computer-Aided Design and Manufacturing) fixed prosthesis : current situation in Madagascar

Research article

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Abstract

CAD/CAM or Computer Aided Design and Fabrication is a technique used in dentistry to design and fabricate crowns, bridges and veneers in fixed prosthetics. This approach enables good prosthetic results to be achieved, and is highly practical and comfortable for both odontostomatologists and patients. The aim of this study was to describe the knowledge and practice of CAD/CAM fixed prosthodontics in the cities of Fianarantsoa and Antananarivo.

It was a descriptive cross-sectional study involving 81 registered odontostomatologists who agreed to take part in the survey, and those who passed through the study sites, did not fill in their forms correctly and had never heard of CAD/CAM were excluded.

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The results showed that 35.8% of odontostomatologists were familiar with CAD/CAM and 11.1% of them used it for the fabrication of fixed prostheses such as single crowns (100%), inlays, onlays and veneers (88.8%) and multi-unit restorations (55%). Indirect CAD/CAM was most widely used (100%), and its use was highly correlated with participation in specific CAD/CAM training courses (p=0.000) and knowledge of CAD/CAM (p=0.001). Practitioners stated that this system offered time savings and improved ergonomics.

We therefore suggest that odontostomatologists attend regular training courses to keep abreast of technological advances. The installation of this system at the CHU and the dental school in Madagascar could improve this situation.

***Key words**: CAD/CAM, fixed prosthesis*

Introduction

CAD/CAM, which stands for computer-aided design and manufacture, encompasses all the equipment used in the field of dentistry by the digital chain, from modelling to the manufacture of dental prostheses [1]. In fixed prosthetics, CAD/CAM is used to produce inlays, onlays, veneers, crowns, inlay-cores and bridge frameworks, and to improve the precision of fit. According to a 2014 study, prostheses fabricated by machining have a more accurate and better marginal fit (48 ± 25µm) compared to conventionally fabricated prostheses (74 ± 47µm)[2].The improvement in the quality of conjoined prostheses comes from the reproducibility, reduction and simplification of shaping steps.

Today, many dental practices and laboratories are equipped with this CAD/CAM system to produce dental prostheses. In France, only 3% of dentists have adopted a fully digital dental practice, according to JF Choura [3]. The rate of CAD/CAM use was 40%, of which more than half of these practitioners owned a machining centre in 2017[4].

In Switzerland, a survey of members of the Swiss Dental Association revealed that 23% of practices surveyed were equipped with a chairside

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CAD/CAM system [5]. In addition, a survey of US Navy dental clinics and laboratories confirmed that, as of June 2017, more than a third of indirect restorations supplied (38.1%) were fabricated by a CAD/CAM system [6].

Clearly, many advances and innovations will flow from this technique. However, few studies have been conducted on CAD/CAM in Madagascar. We hypothesized that the transition to digital prosthodontics represents a delicate transition for odontostomatologists in Madagascar. The overall aim of this study was to describe awareness and practice of the CAD/CAM system for fixed prosthetics in the cities of Fianarantsoa and Antananarivo.

Methodology

Study location : this study was carried out in dental practices in the cities of Fianarantsoa and Antananarivo.

Type of study : this is a cross-sectional prospective descriptive study.

Study period : the survey was conducted over a 6-week period, from June 12 to July 21 -2023.

Study population : the study population consisted of all odontostomatologists in the cities of Fianarantsoa and Antananarivo.

Inclusion criteria : registered odontostomatologists who cooperated with the survey.

Exclusion criteria : odontostomatologists passing through the study sites, who had not correctly filled in their forms and had never heard of CAD/CAM were excluded.

Sample size : our sampling was exhaustive, with a sample size of 81 odontostomatologists.

Studied variables

The following independent variables were taken into account in this study:

- gender,
- age group,
- length of practice,

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- practice area,
- type of fixed prosthesis used
- type of CAD/CAM.

The dependent variables were as follows:

- odontostomatologists' knowledge of the CAD/CAM system
- odontostomatologists' use of the CAD/CAM system.

Data collection

In Fianarantsoa, data were collected using a questionnaire-interview survey of odontostomatologists. In Antananarivo, however, the distribution of the forms was entrusted to a trustworthy person, supported by a telephone call to introduce him/herself to the odontostomatologists; the survey was carried out by self-administration, i.e. we collected the survey forms when the odontostomatologists had already filled them in.

Data processing and analysis

The data collected were entered on the computer using Microsoft Word and Excel. Statistical analysis was performed using SPSS 20.0 (statistical package for the social science) on Windows. Descriptive statistics presented the characteristics of participating odontostomatologists, and frequency tables were generated to illustrate responses to questions. The chi-square test was used for bi-variate analysis, and a p-value of less than 0.05 was considered significant.

Ethical and deontological considerations

Authorization to carry out the survey was granted by the Institut d'Odonto-Stomatologie Tropicale de Madagascar and the Ordre National. Odontostomatologists who gave their consent were surveyed. The confidentiality of data and the anonymity of respondents were respected throughout the study.

Conflict of interest : none

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Results

Table I : distribution of odontostomatologists by socio-professional profile

Socio-professional profile	Effective (n)	Proportion (%)
Gender		
Male	42	51.9
Feminine	39	48.1
Age range		
Under 34	29	35.8
35 and over	52	64.2
Sector of practice		
Public	23	28.4
Private	56	69.1
Military	2	2.5
Length of service		
Less than 10 years	32	39.5
11 to 20 years	27	33.3
21 years and over	22	27.2
Place of service		
Fianarantsoa	15	18.5
Antananarivo	66	81.5

Table II : distribution of odontostomatologists according to place of training and completion of specific CAD/CAM training courses

Training	Effective (n)	proportion (%)
Training location		
Madagascar	69	85.2
Abroad	3	3.7

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Madagascar and abroad	9	11.1
Total	81	100
Follow-up to specific CAD/CAM training courses		
Yes	29	35.8
No	52	64.2
Total	81	100

Table III : distribution of odontostomatologists according to knowledge and practice of the CAD/CAM system

	Yes n(%)	**No n(%)**	**Total n(%)**
Knowledge of the CAD/CAM system (exact answer on types and steps to follow)	29(35.8)	52(64.2)	81(100)
Practice of the CAD/CAM system	9(11.1)	72(88.9)	81(100)
If yes, types of CAD/CAM practiced			
Direct CAD/CAM	2 (22.2)	7 (77.8)	9 (100)
Semi-direct CAD/CAM	4 (44.4)	5(55.6)	9 (100)
Indirect CAD/CAM	9 (100)	0(0)	9 (100)
types of fixed prosthesis performed			
Full-coverage crown	9 (100)	0(0)	9 (100)
Partial veneer crown	8 (88.8)	1 (11.2)	9 (100)
Substitute crown	6 (66.6)	3 (33.4)	9 (100)
Bridge	5 (55.5)	4 (44.5)	9 (100)

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Table I: distribution of odontostomatologists (n=72) who do not use the CAD/CAM system, by reason for practice

Reasons for not using CAD/CAM	**Effective n=72**	**Proportion (%)**
Lack of training		
Yes	53	73.6
No	19	26.4
Financial reason		
Yes	59	81.9
No	13	18.1
Profitability problem		
Yes	40	55.6
No	32	44.4
Dependency		
Yes	2	2.8
No	70	97.2

Table V : distribution of odontostomatologists according to the change felt since the introduction of CAD/CAM fixed prosthetics (n=9)

	Yes n (%)	**No n(%)**	**Total n (%)**
Time saving	9 (100)	0 (0)	9 (100)
Better ergonomics	9 (100)	0 (0)	9 (100)
Greater patient comfort	7 (77.8)	2 (22.2)	9 (100)
Longer prosthesis life	7 (77.8)	2 (22.2)	9 (100)
Greater precision	9 (100)	00	9 (100)

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Better aesthetics	9 (100)	00	9 (100)

Table II: distribution of OS according to the relationship between fixed prosthetic practice and knowledge of the CAD/CAM system

CAD/CAM knowledge	Practice of fixed prosthetics with CAD/CAM systems			
	Yes n(%)	**No n(%)**	**Total n(%)**	**p**
Yes	8 (27.6)	21 (72.4)	29 (100)	0.001
No	1 (1.9)	51 (98.1)	52 (100)	

Table VII : distribution of odontostomatologists according to knowledge and practice of the CAD/CAM system and training

	Knowledge of the CAD/CAM system				**CAD/CAM system practice**			
	Yes n(%)	**No n(%)**	**Total n(%)**	**p**	**Yes n(%)**	**No n(%)**	**Total**	**p**
Training location								
Madagascar	18 (26.1)	51 (73.9)	69 (100)	0.000	7 (10.1)	62 (89.9)	69 (100)	0.457
Abroad	3 (100)	0 (0.0)	3(100)		1 (33.3)	2 (66.7)	3(100)	
Madagascar and abroad	8 (88.9)	1 (11.1)	9 (100)		1 (11.1)	8 (88.9)	9 (100)	
Specific training in CAD/CAM								
Yes	6 (100)	0 (0.0)	6(100)	0.001	9 (64.3)	5 (35.7)	14(100)	0.000
No	23 (30.7)	52 (64.2)	75 (100)		0 (0)	67 (100)	67 (100)	

Discussion

In this scientific study, we surveyed 91 odontostomatologists, including 15 (18.5%) in Fianarantsoa and 66 (81.5%) in Antananarivo, to describe their knowledge and practice of CAD/CAM in fixed prosthetics.

- **Socio-professional profile of odontostomatologists**

The study reported a higher proportion of males (51.9%), with a sex ratio of 1.07. This is in line with the study by Guinan JC et al, who found a value of 56.7% in 2022 in Côte d'Ivoire[7]. We can say that even if all odontostomatologists had access to the same CAD/CAM tools and software, men were more likely to use new technologies to design and manufacture fixed dental prostheses.

Sixty-four point two percent (64.2%) of respondents were over 35, with an average age of 44.5. This result is similar to that of Hélène N in 2022, where the over 33 age group was predominant, with a rate of 62.5%[8].

Sixty-nine point one percent (69.1%) of respondents worked in private dental practices and 28.4% in public dental practices. This is justified by the fact that experienced graduates tend to promote the opening of their own private dental practices. These results are similar to those of Amrani Alaoui et al in Morocco in 2022, who reported that 56% of respondents worked in private dental practices and 30% in public dental practices[9].

Most Odontostomatologists (39.5%) had been practicing for less than 10 years.

Similar assertion, a study conducted by Mbede Net al, in 2022, in Yaoundé showed that 63% of OSs had been practicing for less than five years [10].

Nearly all participants (85.2%) received their initial training in Madagascar, and only 14.8% obtained their diploma abroad. Not only for financial reasons (tuition fees, cost of living), but also because of geographical distance, odontostomatologists may be discouraged from pursuing their studies abroad. Whereas in Romania, according to a study published in September 2017, a third of OSs graduated abroad [11].

➢ **Knowledge of the CAD/CAM system for fixed prosthetics**

Of those surveyed, only 35.8% knew exactly what the CAD/CAM system was (type of CAD/CAM and the steps involved in producing fixed prostheses using this system) (Table III). This could be explained by the fact that knowledge of new technologies depends on the availability of such training and awareness in the country. In addition, some odontostomatologists wanted to use more traditional methods in their practice. This rate of knowledge remains very low compared to that of Janani in 2018,who revealed that in France, all practitioners, declared 100% knowledge of CAD/CAM regardless of their geographical location[12].

Knowledge of the CAD/CAM system is very significantly linked to participation in specific CAD/CAM system training (p=0.001) and highly significant with training location with a p=0.000 (table 8). Training enables staff to acquire new knowledge in order to improve their practice. This result corroborates with the study carried out in 2017 in France, where one practitioner in two had undergone specific CAD/CAM training [13].

➢ **Use of the CAD/CAM system in fixed prosthetics**

In this study, 11% of dental surgeons used the CAD/CAM system in fixed prosthetics, while 89% of dental surgeons surveyed said they did not. This rate of non-use of the CAD/CAM system in this study is very high compared with a study carried out in the UK, where only 55.6% did not use CAD/CAM [14].

According to practitioners who were not CAD/CAM users, the main obstacles to CAD/CAM were high costs (81.9%), lack of training for 73.6% of OS; profitability problems (55.6%) and dependency (2.8%) (Table IV). The adoption of new technologies could take time and depend on various factors such as access to training, resources and individual preferences. This result corroborates with that of Petridis in 2016, who argued that in the UK, various reasons explain why some practitioners did not use CAD/CAM, but the majority reason was the cost of CAD/CAM machines and lack or absence of training for 55.6% of participants [14].

For dental surgeons using the CAD/CAM system, the indirect technique was the most widely used for the design and manufacture of their fixed prosthesis

(100%) (TableIII). This means that ownership of CAD/CAM equipment in the dental practice is low. These results are at odds with that of Jananien 2018, where 25% of practitioners produced their prosthesis by CAD/CAM indirectly[12]. However, the indirect technique only concerns the laboratory part, and does not change the daily practice of odontostomatologists. Indeed, many odontostomatologists who are not CAD/CAM users may have practised indirect CAD/CAM without being aware of it. This bias may have distorted the survey results.

The total (100%) and partial (88.8%) veneering crown, the substitution crown (66.6%) and the bridge (55.5%) were fabricated using the CAD/CAM system (Table III). These results are in line with those of ElkriefM in 2017, where 88% of practitioners used it for fixed unit prosthetics, 59% for fixed plural prosthetics and 56% for restorative dentistry such as inlays, onlays and veneers[4]. Another study conducted by Fabry J in 2018 reported that, in terms of clinical application, 98% of the Odontostomatologists surveyed used chairside CAD/CAM for the fabrication of single-unit prosthetic crowns and for inlay and onlay restorations[15].

All practitioners confirmed that using the CAD/CAM system in fixed prosthetics offers time savings, improved ergonomics, prosthetic precision and also better aesthetics. Seventy-seven point eight percent (77.8%) of odontostomatologists added that CAD/CAM improved patient comfort and prosthetic longevity. These advantages were also reported by Janani et al. in their study, albeit to a lesser extent[12].

The use of CAD/CAM in fixed prosthetics was strongly correlated with participation in a specific training course ($p=0.000$) and knowledge ($p=0.001$) of this system (table 6).This could be explained by the fact that it is continuing education that enables odontostomatologists to keep up to date with technological advances and to understand the best practices and protocols recommended for achieving optimal aesthetic and functional results with dental CAD/CAM. The lack of willingness to train in new dental technologies may partly explain the reduced presence of CAD/CAM in dental practices [16].

Conclusion

CAD/CAM is a technology that combines the use of intra-oral scanners, computer-aided design software and a machine to produce dental prostheses. It is an undeniable advance in the daily practice of odontostomatologists, and this study has examined the case of Madagascar in relation to this technology.

The majority of odontostomatologists in Fianarantsoa and Antananarivo are still less familiar with and practise CAD/CAM. However, working with this system is simpler, faster and more efficient. The odontostomatologists who used them produced all kinds of fixed prostheses, in the same way as elsewhere.

In Madagascar, the major obstacle to the use of CAD/CAM is the investment required to set it up, not to mention the training time needed to master the technique. This obstacle is not irreversible, however, as the price of the machines will evolve in the same direction as any IT system, and prices will become attractive.

The future of CAD/CAM in dentistry is promising, as this technique offers many advantages to odontostomatologists. The integration of CAD/CAM equipment into public health establishments and dental schools in Madagascar will facilitate access to digital technology for practitioners and students, ensuring better patient care in fixed prosthetics.

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