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Performance of Atraumatic Restorative Treatment (ART) depending on operator-experience

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Abstract

Objectives: Oral health care is not of major interest in developing countries because of lack of infrastructure and professional manpower. Therefore, atraumatic restorative treatment (ART) was introduced by the World Health Organization to be performed by dental auxiliary personnel. The aim of this study was to evaluate the performance of ART depending on operator-experience in The Republic of The Gambia.
Methods: One hundred twenty-eight newly inserted restorations were followed up for 12 months using the clinical ART index in a prospective and blinded study design. The patients were randomly assigned to operators. The clinical performance was compared among three groups: trainees, experienced Community Oral Health Workers (COHW), and professional dentists. The difference in success rates was calculated at a 95 percent confidence interval.
Results: There was a statistically significant difference between trainees and dentists in performing leakage/gap-free one-surface restorations ($P < 0.05$). No significant differences were found between the two groups of auxiliaries (trainees versus experienced COHWs, $P > 0.05$). Finally, both groups – experienced COHWs and dentists – performed restorations not showing statistically significant differences ($P > 0.05$).
Conclusions: For The Republic of The Gambia – especially for areas with underdeveloped medical infrastructure – training and assignment to perform ART can be recommended for auxiliary dental staff of Community Oral Health Workers.

Introduction

In industrial countries, the decline of caries in adolescents within the last decades is apparently a result of wide use of fluorides (1) and enhanced public oral health care (2). However, in many African countries, the vast majority of carious lesions remain untreated because of missing infrastructure and manpower (3). Atraumatic restorative treatment (ART) was developed in the mid 1980s to offer practical dental caries treatment in regions of scarce supply of water and electricity and unavailability of dental professionals (4). It is now introduced in many developing countries worldwide with emerging dental health care (5). By a minimal intervention cavity preparation technique, and by using hand instruments only, the treatment approach is intended to be performed by dental auxiliaries (4,6). A glass-ionomer cement is used as restorative material. The technique has shown to be most effective in single-surface cavities and in pediatric dentistry (7).

Inconsistent data are available on the performance of ART regarding operator-experience. Some studies reported significantly different clinical performance comparing professional dentists and auxiliary dental staff (8), while other investigators did not find significant differences (9).

In The Republic of The Gambia, ART was established in 1995 by dentists and senior dental students in rural areas of the Central River Region. Since 2001, auxiliary dental staff

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was trained to become Community Oral Health Workers (COHW) in 3-month courses. This applied to state enrolled nurses (SEN) and state registered nurses (SRN).

To evaluate the effectiveness of the Gambian ART training courses, it was the aim of this study to compare the clinical performance of ART – dependent on the level of expertise – after a 12-month follow-up. As a null hypothesis, it was assumed that no difference existed in the quality of ART restorations comparing supervised trainees, experienced COHW, and professional dentists as operators.

Methods

The survey was initiated during a 3-month ART training course for Gambian SENs/SRNs in a prospective study design according to the Strengthening the Reporting of Observational Studies in Epidemiology statement (10). The curriculum included the manual for ART (11) and is consisted of a month of training in biological and basic dental sciences focusing on dental caries and their clinical management, followed by a month of simulated treatment in extracted teeth and mutual practical exercises. The third month of the training course was focused on supervised patient-treatment.

After graduation, COHW usually extend their stay at the training center to gain advanced clinical experience before returning to the health center from where they came from to establish a new dental station.

During the third month of training and the 1-year post graduate period, all patients attending one of the rural health centers, the Jahali Health Centre, for dental restorative treatment giving their informed consent were included in the study. All participants of the training course and all COHW extending their stay at the health center after the training were selected for participation in the study. Before initial dental examination, the patients were randomly assigned to an operator and matched by gender to avoid selection bias. A matching by age was not feasible as patients living in rural areas of The Gambia usually have no access to central registers to obtain exact birth dates. One hundred thirty-one one-surface (classes I and V) and multi-surface (classes II and III) restorations were performed by either 10 trainees (group 1) or seven experienced COHW (group 2) or by the two dentists who supervised the ART training (group 3). Qualitatively, the restorations were observed during the follow-up examination using the clinical ART (cART) index, modified for the atraumatic restorative treatment approach according to the Ryge/United States Public Health Service criteria. The latter were developed in the early 1970s for evaluation of the clinical quality of restorations and have been used worldwide because of the clear rating system and decision tree (12,13) (Table 1). To avoid information bias, a blinded examiner who was not part of the COHW training course conducted the evaluation. Fillings were rated as failure if fracture or loss of restoration, marginal leakage or gap, and/or secondary caries had occurred; otherwise they were labeled as success. ART was additionally analyzed concerning cavity extension in multi-surface restorations to identify potential confounder impact. A restoration was classified as "small" when it involved two tooth surfaces and "large" in case of more than two tooth surfaces.

Ethical approval and permission of the ART training courses and their clinical evaluation were obtained by the Department of State for Health, Social Welfare and Women's Affairs (Banjul, The Gambia). Statistical significance was calculated with Prism4 for Macintosh (Graphpad Software Inc., San Diego, CA, USA). For matching comparison of the

Table 1 Distribution of ART Failure Criteria According to the Modified Clinical ART Index after 12 Months

Quality parameter	Rating	USPHS compatibility	Success versus failure	One–surface ART (%)	Multi-surface ART (%)
Anatomic form	Correct anatomic form	Alpha	Success	35 (79.5)	52 (61.9)
	Incorrect filling form	Bravo	Success	7 (15.9)	18 (21.4)
	Fracture or loss (partial or total)	Charlie	Failure	2 (4.5)	14 (16.7)
Marginal integrity	Margin not detectable	Alpha	Success	21 (48.8)	25 (32.9)
	Margin detectable in fissure ramifications	Bravo	Success	15 (34.9)	4 (5.3)
	Margin detectable in areas with no fissure	Bravo	Success	3 (7.0)	36 (47.4)
	Margin detectable more than one third of the circumference	Charlie	Success	1 (2.3)	9 (11.8)
	Marginal leakage/gap	Charlie	Failure	3 (7.0)	2 (2.6)
Marginal discoloration	No discoloration	Alpha	Success	27 (61.4)	37 (44.0)
	Discoloration up to one third of the circumference	Bravo	Success	10 (22.7)	21 (25)
	Discoloration at more than one third of the circumference	Charlie	Success	5 (11.4)	23 (27.4)
	Secondary caries	Delta	Failure	2 (4.5)	3 (3.6)

USPHS ratings: Alpha, excellent; Bravo, defective filling, clinical acceptable; Charlie, defective filling, acceptable after correction; Delta, replacement.
ART, atraumatic restorative treatment; USPHS, United States Public Health Service.

different study groups, an ANOVA test was used. Analysis of the clinical outcomes was performed by a 95 percent confidence interval (CI) for the difference in success rates ($P < 0.05$). Therefore, proportions of success were calculated as the ratio between success and failure ratings of each failure criterion per group and in turn, this established the 95 percent CI. Statistical significance was determined when the CI was below or above zero.

Results

No statistically significant differences were observed concerning patients gender when comparing the three study groups ($P > 0.6$). After 12 months, 128 of 131 restorations (2.9 percent lost to follow-up) could be evaluated. The main reason for missing cases was migration of patients into cities. Absolute numbers of restorations per coding and percentage are summarized in Table 1. The anatomical form of one–surface ART was rated successful in 42 out of 44 restorations (95.4 percent); multi-surface restorations showed success in 70 out of 84 fillings (83.3 percent). Fracture or loss of restoration occurred in two (4.5 percent) and 14 restorations (16.7 percent), respectively. One-surface restorations showed clinically acceptable margins in 41 restorations (93 percent; leakage or gap: 7.0 percent); good marginal integrity of multi-surface restorations was documented in 82 fillings (97.4 percent; leakage or gap: 2.6 percent). Secondary caries developed in two teeth (4.5 percent, one-surface) and three teeth (3.6 percent, multi-surface), respectively. Comparing small and large restorations, no statistically significant differences could be detected regarding the anatomic form of the restorations, marginal integrity and development of secondary caries ($P > 0.7$).

After 12 months, the clinical outcome of restorations according to ART showed no significant differences between operator groups 1 and 2 regarding the failure criteria in small and large restorations. Similarly, no statistically significant differences were found between groups 2 and 3. In contrast, there was a statistically significant difference between groups 1 and 3 in performing leakage/gap-free one-surface restorations in favor of group 3 (professional dentists, $P < 0.05$). However, this effect could not be seen in multi-surface restorations. Furthermore, no operator effect between these groups was present in the coding of the anatomical form and in the development of secondary caries (Table 2).

Discussion

The common colonial heritage of African countries regarding public health care shows uniform key characteristics. General treatment on a more than emergency basis is predominantly provided in few well-equipped hospitals in urban areas and is not available and/or affordable for the vast majority of the rural population (14). Moreover, maintenance of the hospitals often devour over 80 percent of the entire budget for medical services and focus on the treatment of life-threatening diseases (15). Primary oral health care is therefore not a priority in national health plans usually facing emerging diseases like the acquired immunodeficiency syndrome and tuberculosis. In this respect, ART is a milestone in

Table 2 Statistical analysis of the clinical performance comparing trainees (group 1) and experienced Community Oral Health Workers (group 2), and dentists (group 3); proportion (of success) represents the ratio of successful (nominator) versus failure ratings (denominator) of each failure criterion per group

ART cavity design	Failure criteria	Proportion	Operator comparison	Confidence interval	Standard error	*P* value
One-surface	Fracture/loss	Group 1: 0.81	Group 1 versus 2	–0.2897-0.0385	0.0837	>0.05
		Group 2: 0.93	Group 1 versus 3	–0.2863-0.1708	0.1264	>0.05
		Group 3: 0.85	Group 2 versus 3	–0.2939-0.1197	0.1055	>0.05
	Marginal leakage/gap	Group 1: 0.84	Group 1 versus 2	–0.2904-0.0048	0.0753	>0.05
		Group 2: 0.98	Group 1 versus 3	–0.3037-0.0163	0.0733	<0.05
		Group 3: 1.0	Group 2 versus 3	–0.0163-0.0507	0.0171	>0.05
	Secondary caries	Group 1: 1.0	Group 1 versus 2	–0.0053-0.1087	0.0291	>0.05
		Group 2: 0.95	Group 1 versus 3	0	0	>0.05
		Group 3: 1.0	Group 2 versus 3	–0.0053-0.1087	0.0291	>0.05
Multi-surface	Fracture/loss	Group 1: 0.78	Group 1 versus 2	–0.3669-0.2975	0.1695	>0.05
		Group 2: 0.81	Group 1 versus 3	–0.4657-0.4213	0.2263	>0.05
		Group 3: 0.8	Group 2 versus 3	–0.0939-0.0689	0.0415	>0.05
	Marginal leakage/gap	Group 1: 1.0	Group 1 versus 2	0	0	>0.05
		Group 2: 1.0	Group 1 versus 3	0	0	>0.05
		Group 3: 1.0	Group 2 versus 3	0	0	>0.05
	Secondary caries	Group 1: 1.0	Group 1 versus 2	0	0	>0.05
		Group 2: 1.0	Group 1 versus 3	0	0	>0.05
		Group 3: 1.0	Group 2 versus 3	0	0	>0.05

ART, atraumatic restorative treatment.

community dentistry worldwide. Advantage of ART is a painless cavity preparation procedure using hand instruments with usually no need for local anesthesia resulting in high patient acceptance. Further benefits are the use of glass-ionomer cement as an appropriate biomaterial, minimal requirements of infrastructure, and its efficiency in terms of primary health care (7). A meta-analysis of survival rates of single-surface restorations in the permanent dentition as inserted according to ART and using high-viscosity glass-ionomer cements showed the following (7): after 4 years of function, they ranged between 80 percent in Syria, 86 percent in China, and 92 percent in Malaysia. Evaluation data of class III restorations are inconsistent as yet, and longitudinal data in the permanent dentition are rare. Survival rates of 71 percent after 3 years and of 68 percent after 6 years in the same study group have been reported (16).

In developing countries, general medical treatment in rural health centers is usually provided by nurses in the absence of physicians (17). Because diagnostic or therapeutic dental skills are not part of the training curricula for auxiliary medical staff, the implementation of dental treatment into basic health care is, for many countries, out of reach (18). As part of the binational Witten/Herdecke University Gambia-DentCare Programme, the government of The Republic of The Gambia established the framework for developing a countrywide oral health care system by implementing an additional 3-month training curriculum of graduated SENs/SRNs, which afterwards will be certified COHW. They provide for oral health education, ART, and emergency care. The results of this study show a promising quality of restorations even if performed by inexperienced but well-educated and professionally supervised trainees. No clinically significant differences were detected comparing experienced COHW and dentists. These findings are in accordance with early ART studies evaluating auxiliary dental staff trained in ART and professionals. Phantumvanit et al. presented results from a study conducted in Thailand, where they could show that the survival curves of one–surface ART restorations after 3 years as inserted by dental nurses were actually about 5 percent higher than restorations inserted by dentists (6). Although our results did not reveal significant differences in survival between small and large multi-surface restorations, Lo et al. demonstrated different survival rates depending on cavity extension with a high relative risk of failure of 5.9 for large class I cavities (8). Different clinical outcomes could result from diverse national and cultural conditions, different training curricula, varying medical backgrounds of the trainees, different physical properties of the glass-ionomer cements used, or to the different observation periods of the studies. A 12-month observation period in our study appears to be rather short compared with other medium–term follow-up assessments. However, the duration of the study was chosen to avoid medium- or long-term functional influences of individual wear on the deterioration of restorations and to demonstrate operator's influence. This could be shown in the marginal adaptation of the restoration material in one-surface restorations, especially in trainees. Practical exercises in extracted teeth before clinical treatment should focus on the improvement of this failure criterion. Within these limits, it could be concluded that a 3-month curriculum teaching general medical and basic dental science, practical exercises using simulation models, as well as supervised clinical practice appeared to be successful in training auxiliary dental staff. It seems appropriate to build up an area-wide basic oral health care system in The Gambia.

The results support the following clinical conclusions:

- Training of COHW as auxiliary dental staff with minor clinical experience performed well under professional supervision. Patient treatment should therefore be included in training curricula.
- Clinically experienced dental auxiliaries performed equally well as compared to dentists even without continuous supervision. In this respect, their service in the early dental caries treatment using ART is a promising concept for the establishment of basic oral health care in underserved areas.
- Fracture or loss of restorations, marginal leakage or gaps and the development of secondary caries are the most important reasons for failure of ART. Focusing on the accurate treatment for avoiding these complications should be the key goals of practical ART training and periodical post graduate continuing education courses.

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Appendix 1: GambiaDentCare training program of community oral health workers

Month	Lectures	Excercises	Examinations
1	Anatomy, Oral (patho-)biology, Physiology, Propaedeutic dentistry	Oral health education (mutual practical exercises)	Learning outcome assessment (knowledge and skills)
2	Clinical dentistry, Emergency medicine, Hygiene, Oral medicine, Pharmacology	Simulated treatment (extracted teeth, mutual practical exercises)	Learning outcome assessment (knowledge and skills)
3		Clinical treatment (supervised patients' treatment)	Final examination, state certification