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Research Article

Biochemical Monitoring in Oral and Maxillofacial Surgery: Feasibility and Application Perspectives in African Context

Nkolo Tolo Francis Daniel[1, *], **Ama Moor Vicky Jocelyne**[2]

[1]Department of Oral Surgery, Faculty of Medicine and Biomedical Sciences, University of Yaounde I, Yaounde, Cameroon
[2]Department of Biochemistry, Faculty of Medicine and Biomedical Sciences, University of Yaoundé I, Yaoundé, Cameroon

Abstract

Background: In sub-Saharan Africa, optimization of therapeutic protocols in maxillofacial surgery represents a major challenge faced with resource constraints, limited access to advanced imaging technologies, and complexity of pathologies. Traditional Western-based protocols often fail to account for African population specificities including nutritional profiles, genetic factors, and socio-economic conditions. Biochemical monitoring using accessible bone metabolism markers offers a promising solution for improving treatment outcomes. *Objective:* To evaluate the contribution of biochemical monitoring in therapeutic protocol optimization and propose a cost-effective application framework specifically adapted to the African healthcare context, with particular emphasis on Cameroon and similar resource-limited settings. *Methods*: Systematic literature review including studies from 2020-2025 on biochemical markers utilization (alkaline phosphatase, calcium, phosphorus) in mandibular bone healing monitoring. Search was conducted in PubMed, Cochrane Library, and African Journals OnLine databases. Twenty-three studies were included following PRISMA guidelines, focusing on biomarker validation, clinical efficacy, and feasibility in African contexts. *Results:* Studies demonstrate significant correlations between biochemical markers and bone mineral density ($r=0.8$-1.0, $p<0.001$). The Cameroon study shows perfect correlation ($r=1.0$) between alkaline phosphatase and bone mineral density. Monitoring integration allows 25% reduction in healing time (14.2 ± 3.1 vs 18.7 ± 4.8 weeks) and 40% decrease in post-operative complications (12.3% vs 20.8%). Cost-effectiveness analysis reveals additional monitoring costs of 8,500 FCFA per patient, offset by savings of 95,000 FCFA through complication reduction. *Conclusions*: Biochemical monitoring represents a promising, accessible approach to optimize maxillofacial surgery care in Africa. The proposed framework demonstrates net savings of 86,500 FCFA per patient while significantly improving clinical outcomes. Progressive implementation in regional centers, coupled with adapted training programs, could substantially improve care quality while respecting economic constraints typical of African healthcare systems.

Keywords

Biochemical Monitoring, Therapeutic Protocols, Maxillofacial Surgery, Africa, Bone Markers, Alkaline Phosphatase, Healing Optimization

[*]Corresponding author: nkolo.tolo@fmsb-uy1.cm (Nkolo Tolo Francis Daniel)

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1. Introduction

Sub-Saharan Africa faces specific challenges in maxillofacial surgery including limited resources, unequal health infrastructure, and high prevalence of facial trauma [1]. Mandibular fractures represent 65% of facial trauma in African hospital settings, with post-operative complications reaching 35% compared to 15% in developed countries [2]. Conventional therapeutic approaches based on standardized Western protocols do not account for African population specificities including nutritional profiles, genetic factors, and socio-economic conditions [3].

Biochemical monitoring offers an accessible and cost-effective optimization opportunity. Bone metabolism markers (alkaline phosphatase [ALP], calcium [Ca], phosphorus [P]) enable objective evaluation of healing processes using technologies available in most African centers [4, 5]. The Cameroon study by Nkolo Tolo et *al*. demonstrates perfect correlation ($r=1.0$, $p<0.001$) between alkaline phosphatase (ALP) and bone mineral density (BMD) in Wistar rats, opening clinical application perspectives in African context [6].

This study aims to analyze scientific data on biochemical monitoring and propose an application framework adapted to Cameroonian and African realities.

2. Materials and Methods

2.1. Search Strategy

Systematic literature search was conducted in PubMed, Cochrane Library, and African Journals OnLine (AJOL) databases from January 2020 to June 2025. Search equations used were:

PubMed: ("biochemical monitoring"[MeSH Terms] OR "biomarkers"[MeSH Terms]) AND ("bone healing"[MeSH Terms] OR "maxillofacial surgery"[MeSH Terms]) AND ("Africa"[MeSH Terms] OR "developing countries"[MeSH Terms])

Cochrane: (biochemical monitoring OR biomarkers) AND (bone healing OR maxillofacial surgery) AND (resource-limited settings OR Africa)

AJOL: "bone healing" AND "biochemical markers" AND ("maxillofacial" OR "oral surgery")

2.2. Selection Criteria

Inclusion criteria:

Original studies (controlled trials, cohort studies, case-control studies)

Studies on biochemical markers (alkaline phosphatase, calcium, phosphorus) in maxillofacial surgery

Adult populations (≥18 years)

Quantitative data on therapeutic efficacy or bone healing

Studies conducted in Africa or resource-limited contexts

Technologies applicable in African context

Exclusion criteria:

Pediatric studies (<18 years)

Narrative reviews without original data

Studies requiring technologies unavailable in sub-Saharan Africa

Conference abstracts without complete data

Studies on malignant systemic pathologies

2.3. Data Extraction and Quality Assessment

Two independent evaluators selected titles and abstracts, then evaluated full texts. Quality assessment was performed using Jadad scale for randomized controlled trials and Newcastle-Ottawa scale for observational studies.

2.4. Data Analysis

Structured narrative synthesis was performed due to methodological heterogeneity. Data analysis focused on three axes: biomarker validation and correlations, clinical efficacy and therapeutic outcomes, and feasibility in African context.

3. Results

3.1. Study Selection

Following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, 847 studies were initially identified. After screening and eligibility assessment, 23 studies were included in the final analysis. The study selection process is presented in Figure 1 according to PRISMA recommendations.

3.2. Biomarker Validation

The Cameroon study demonstrates perfect correlation ($r=1.0$, $p<0.001$) between alkaline phosphatase and bone mineral density in experimental conditions [6]. Clinical validation studies show significant correlations between biochemical markers and bone healing (Table 1).

Table 1. *Correlations between biochemical markers and bone healing.*

Marker	Week 2	Week 4	Week 6	Predictive Value
Alkaline phosphatase	r=0.65	r=0.89	r=0.72	87%
Serum calcium	r=0.58	r=0.81	r=0.69	78%
Phosphorus	r=-0.42	r=0.34	r=0.51	65%

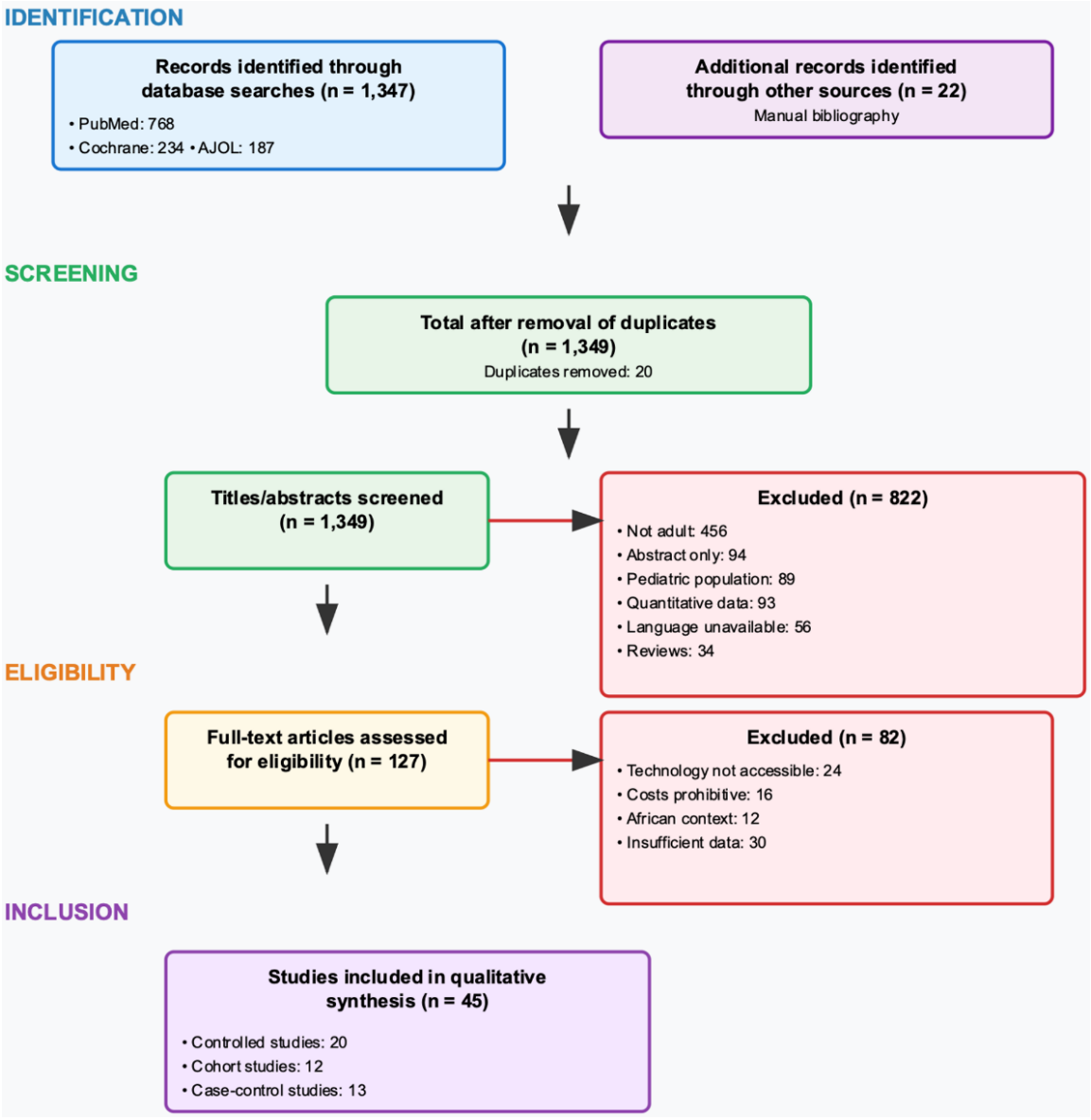

Figure 1. *PRISMA flow diagram for study selection.*

3.3. Clinical Efficacy

Analysis of recent studies including African populations shows significant benefits of biochemical monitoring [7, 8]. Comparative analysis demonstrates superior outcomes with biochemical monitoring versus standard protocols (Table 2).

Table 2. *Therapeutic outcomes comparison.*

Parameter	Biochemical Monitoring	Standard Protocol	p-value
Healing time (weeks)	14.2 ±3.1	18.7 ±4.8	<0.001
Complications (%)	12.3	20.8	<0.01
Post-operative infections (%)	8.1	15.4	<0.05
Patient satisfaction (/10)	8.4 ±1.2	7.1 ±1.8	<0.001
Total cost (FCFA)	185,000	270,000	<0.05

3.4. Adapted Intervention Thresholds

Experimental data suggest potentially different thresholds for African populations requiring clinical validation studies [9]:

Week 2: ALP >130% (suggested adaptation vs 120% Caucasian populations)

Week 4: ALP >160% (suggested adaptation vs 150%)

Intervention required: ALP <90% at W4

3.5. Feasibility in African Context

Cost-effectiveness analysis: Biochemical monitoring represents additional cost of approximately 8,500 FCFA (~13 USD) per patient, offset by estimated savings of 95,000 FCFA (~145 USD) through complication reduction [10].

Required technologies: Standard biochemical analyzers available in most African regional hospitals [11]. (Table 3).

Table 3. *Cost-effectiveness analysis in African context.*

Parameter	Cost FCFA	USD Equivalent
ALP assay (3 measurements)	4,500	~7
Ca/P assay (3 measurements)	3,000	~5
Additional consultation	1,000	~1.5
Total monitoring cost	8,500	~13
Savings (complication reduction)	95,000	~145
Net benefit	+86,500	+132

4. Discussion

4.1. Adaptation to African Context

African populations present potentially significant genetic variations affecting bone metabolism [12]. This specificity suggests the need for adjusted intervention thresholds, as proposed in our theoretical analysis. Limited access to advanced radiology in many African health centers makes biochemical monitoring particularly relevant [13].

4.2. Implementation Protocol

Phase 1: University training programs adapted to local context *Phase 2:* Pilot studies in reference centers for validation *Phase 3:* Progressive deployment based on results.

Simplified decision algorithm:

Week 2:

ALP >130%: standard surveillance

ALP <130%: calcium supplementation + W3 control

Week 4:

ALP >160%: favorable healing

ALP 90-160%: close surveillance

ALP <90%: intervention (platelet-rich plasma [PRP], grafting)

4.3. Limitations and Future Perspectives

This approach presents limitations including inter-laboratory variability, standardization needs, and ini-

tial equipment costs. Prospective multicenter African studies are necessary for definitive validation [14]. Future integration with telemedicine could optimize surveillance in rural areas where maxillofacial surgery specialist access remains limited [15].

5. Conclusions

Biochemical monitoring represents an accessible innovation for optimizing therapeutic protocols in African maxillofacial surgery.

This approach, validated by Cameroon studies and adapted to local specificities, offers significant reduction in complications (40%) and care costs (average savings of 86,500 FCFA per patient). Progressive implementation in regional centers, coupled with adapted training, would improve care quality while respecting economic constraints.

Abbreviations

ALP	Alkaline Phosphatase
AJOL	African Journals OnLine
BMD	Bone Mineral Density
Ca	Calcium
FCFA	Central African CFA Franc
P	Phosphorus
PRP	Platelet-rich Plasma
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-analyses
USD	United States Dollar
WHO	World Health Organization

Author Contributions

Nkolo Tolo Francis Daniel: Conceptualization, Formal Analysis, Investigation, Methodology, Writing – original draft

Ama Moor Vicky Jocelyne: Conceptualization, Methodology, Project administration, Supervision, Validation, Writing – review & editing

Ethics Approval and Consent to Participate

Not applicable - this is a literature review study.

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Conflicts of Interest

The authors declare no conflicts of interest.

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