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The Ry Cortico-Zygomatic Classification: A Cbct-Based Classification for Immediate-Loading Graftless Full-Arch Maxillary Rehabilitation: A Systemically Driven Cohort Study with Three-Year Follow-Up

Reena Yadav[1*]

[1]Department: Oral and Maxillofacial Surgery and Head and Neck Oncology Consultant, RMS Superspeciality Hospital, Kandivali, Mumbai, Jai Ambe Multispeciality Hospital, Mira Road, Mumbai, India

Author Designation: [1]Maxillofacial Surgeon

*Corresponding author: Dr. Reena Yadav (e-mail: reenamaxfax@gmail.com).

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Abstract **Objectives:** Treating the severely atrophic maxilla is one of the hardest problems in modern implant surgery. While tools such as the Zygoma Anatomy-Guided Approach (ZAGA) have improved our understanding of sinus morphology at individual implant sites, none of the existing classifications fully captures the breadth of cortical anchorage options within a single, arch-level, prosthetically oriented framework. **Objectives:** To introduce and perform an initial clinical evaluation of the RY Cortico-Zygomatic (RY) Classification — a novel four-tier CBCT-based system for atrophic maxillary rehabilitation — and to report implant survival, marginal bone loss, prosthetic outcomes, and patient-reported outcomes at a minimum 36-month follow-up. **Methods:** Retrospective cohort study of 77 consecutively treated, fully edentulous patients (42 males, 35 females, mean age 56.3±8.7 years) who underwent maxillary implant-supported full-arch rehabilitation between February 2020 and February 2023, with follow-up to February 2026. Patients were classified as RY-I (n = 8), RY-II (n = 15), RY-III (n = 22), or RY-IV (n = 32) on pre-operative CBCT. Primary outcomes: cumulative implant survival rate (ISR) and marginal bone loss (MBL) at 36 months. **Results:** 369 implants were placed (102 conventional, 67 pterygoids, 200 zygomatic), all zygomatic fixtures were placed exclusively using the Quickdent Implant System. Overall 36-month ISR was 97.0% (358/369). Category-specific ISR: RY-I 100%, RY-II 98.3%, RY-III 97.7%, RY-IV 95.8%. Mean MBL at 36 months ranged from 0.31±0.12 mm (RY-I) to 0.89±0.31 mm (RY-IV). Sinus complications occurred in 9 patients (11.7%), all of which resolved conservatively. OHIP-14 improved from 38.4±7.2 to 8.6±3.4 at 36 months ($p<0.001$). Interobserver agreement: $\kappa = 0.91$. **Conclusions:** The RY Cortico-Zygomatic Classification offers a simple, reproducible, arch-level CBCT framework for planning graftless rehabilitation of the atrophic maxilla, with excellent interobserver agreement ($\kappa = 0.91$). Across all four categories, implant survival, marginal bone stability and patient-reported outcomes were favourable at 36 months. Prospective multicentre studies are now needed to confirm its prognostic value and clinical utility.

Key Words: Atrophic Maxilla, Zygomatic Implant, Cortical Anchorage, CBCT Classification, ZAGA, Pterygoid Implant, Immediate Loading, RY Classification, Quickdent Implants, Quickdent Zygomatic Implant System, Marginal Bone Loss, Full-Arch Rehabilitation, Patient-Reported Outcomes

INTRODUCTION

Following tooth extraction, progressive resorption of the maxillary alveolar bone and sinus pneumatisation frequently reduce the bone volume available for implant placement [1-2]. Maxillofacial surgeons have historically turned to sinus floor elevation, autogenous grafting, and distraction osteogenesis to reconstruct these deficient sites. These techniques are often successful but carry the burden of patient morbidity, longer treatment duration, and the risk of graft failure [3-4].

Brånemark *et al.* first described zygomatic implants in the early 1990s: instead of rebuilding an atrophic alveolus, longer fixtures (typically 30–52.5 mm) are anchored directly in the dense cortical bone of the zygoma [5]. Immediate prosthetic loading is allowed by this approach and, in the majority of cases, bypasses sinus grafting entirely [6-7].

Three decades of follow-up data have since confirmed survival rates in the 95–98% range across both single and quad-zygomatic configurations [8-10].

Aparicio's 2011 ZAGA classification sorted the palato-buccal contour of the maxillo-zygomatic junction into five types (ZAGA 0-4), helping maxillofacial surgeons decide between intra-sinus, extra-sinus, and bone-guided implant paths [11]. It standardised surgical technique in a way prior frameworks had not done. However, ZAGA was not designed as an arch-level planning guide, it does not evaluate residual alveolar architecture, nasal floor engagement, pterygoid corridor availability, or the overall biomechanical demands of a full-arch prosthesis [12-13].

Some parts of this gap are addressed by other frameworks. The maxilla is divided into premaxillary, premolar, and molar zones according to Bedrossian's staging system [14]. The Landes classification [15] relates zygomatic implant indication to sinus dimensions and residual ridge height. More recently, in 2024, the authors [16] provided promising evidence that Quickdent zygomatic implants achieved 99% survival in 60 patients over 30 months — an important contribution to the evidence base from the Indian clinical context. Yet despite these efforts, a unified CBCT-based system that simultaneously accounts for alveolar support, all available cortical anchorage pathways, and prosthetic biomechanics is still missing. The present work introduces and clinically validates the RY Cortico-Zygomatic Classification — a pragmatic four-tier CBCT-based tool designed to fill that gap — reporting results in 77 consecutive patients over at least 36 months.

A recurring concern in everyday practice is that some clinicians remain hesitant about zygomatic implants, at times regarding them as an unnecessarily aggressive option when other routes appear simpler. Framed correctly, however, the choice is never about zygomatic implants for their own sake: whether the definitive plan calls for anterior conventional implants alone, a zygomatic-only configuration, or a combination of anterior and zygomatic anchorage, every pathway is subordinate to a single governing objective — the biomechanical stability, occlusal scheme, and long-term prosthetic success of the final restoration. The RY Cortico-Zygomatic Classification described in this article is intended to make that decision transparent and reproducible: by mapping a patient's CBCT findings onto one of four tiers, clinicians gain a structured basis for counselling patients on why a particular implant combination has been recommended and what outcome, in terms of implant survival and prosthetic success, they can realistically expect. Both Quickdent Dental Implants TPR and the Quickdent Zygomatic Implant System (Quickdent International) were used across the cohort described in this study, reflecting the RY framework's applicability across the full range of anterior, zygomatic, and combined anchorage strategies.

Aims and Objectives

We had two main goals: to describe the RY Cortico-Zygomatic Classification in adequate detail for others to replicate it, and to report the outcomes of patients managed under its guidance over at least three years of follow-up. Specifically, we aimed to:

- Establish precise CBCT thresholds distinguishing each RY tier from the next
- Monitor cumulative implant survival, marginal bone loss, and stability readings by category
- Describe the prosthetic events, sinus complications, and quality-of-life change using the OHIP-14 index
- Situate RY relative to the established ZAGA classification and clarify how the two systems interact
- Propose a descriptive, testable decision framework for planning graftless maxillary rehabilitation

The Ry Cortico-Zygomatic Classification

The authors developed this classification after systematically reviewing CBCT scans from over 100 consecutive patients presenting with varying degrees of maxillary atrophy. The underlying rationale is straightforward: graftless full-arch rehabilitation, when stripped back to first principles, is always a question of which cortical structures are available to anchor the prosthesis. We identified four such pillars — the residual alveolar cortex, the nasal floor cortex, the pterygoid process cortex, and the cortex of the zygomatic body — and built the classification around which combination of these pillars each patient's anatomy can realistically provide. The resulting four tiers are not arbitrary, each one maps directly onto a distinct implant configuration capable of delivering a rigid, immediately loaded full-arch result.

Before assigning a category, we evaluated each scan for the following: alveolar height and width at standard reference positions, the degree of sinus pneumatisation, nasal floor cortical thickness, the dimensions of the pterygoid corridor, zygomatic body morphology, bone density expressed in Hounsfield units at the planned implant sites, and the projected implant vectors needed to achieve adequate primary stability for immediate loading. This classification is depicted in Table 1. The RY Classification system was named after its author, Dr. Reena Yadav.

Classification reproducibility requires prespecified CBCT anatomical reference points and consistent numeric thresholds for residual ridge height and width. Mixed/borderline anatomy should be assigned using preoperative measurements independently of the implant strategy selected, otherwise treatment choice may circularly define the purported predictor. Adequate cortical anchorage needs an operational measurement-based definition and independent reader testing.

RY-I: Residual Cortical Dominant Maxilla

Patients in this category have lost some alveolar height, but not enough to demand extra-alveolar anchorage. There is still a workable cortical base in the posterior maxilla, and when axial or tilted fixtures are placed using All-on-4® or

Table 1: The RY Classification System

RY Type	Classification	CBCT Features	Available Cortical Anchorage	Recommended Implant Strategy
RY-I	Residual Cortical Dominant Maxilla	Posterior alveolar height ≥8 mm, width ≥5 mm, minimal sinus pneumatisation, adequate bone density	Residual alveolar cortex	4–6 conventional implants (axial/tilted), All-on-4® or All-on-6®
RY-II	Hybrid Cortico-Zygomatic Maxilla	Adequate anterior bone, posterior height <8 mm or width <5 mm, moderate sinus pneumatisation, accessible pterygoid corridor	Anterior alveolar cortex + one zygomatic cortex±pterygoid cortex	2–4 anterior conventional implants + bilateral single zygomatic implants and/or bilateral pterygoid implants
RY-III	Advanced Cortico-Zygomatic Maxilla	Severe posterior atrophy, anterior bone 4–8 mm, marked bilateral sinus pneumatisation	Bilateral zygomatic cortex + nasal cortex±pterygoid cortex	Bilateral single zygomatic implants + pterygoid implants and/or nasal-floor engaging anterior implants
RY-IV	Extreme Atrophic Cortical Rescue Maxilla	Residual alveolar height <4 mm, near-complete maxillary resorption, severe bilateral sinus pneumatisation, no functional anterior support	(more than 2) Bilateral zygomatic cortex (primary)±pterygoid cortex	Quad zygomatic implants (2 per side) with or without pterygoid implants, no conventional alveolar implants

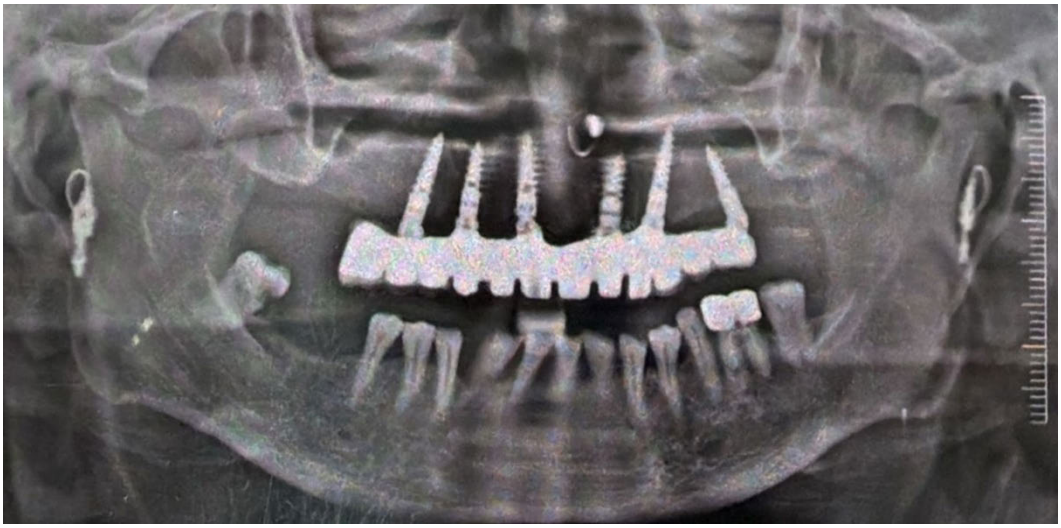


Figure 1: Post-Operative Panoramic Radiograph of an RY-I Patient Following Implant-Supported Full-Arch Maxillary Rehabilitation Using Conventional and Tilted Implants. Note The Absence of Zygomatic Implants, Consistent with The RY-I Classification Criterion of Sufficient Residual Alveolar Anchorage

All-on-6® principles, cross-arch splinting delivers the rigidity needed for same-day loading. Zygomatic implants simply are not required here.

- **CBCT Criteria:** Residual posterior alveolar height ≥8 mm, width ≥5 mm, absence of severe posterior pneumatisation
- **Implant Strategy:** Four to six conventional implants (axial and tilted), no zygomatic implants required
- **Immediate Loading:** Generally, favourable, primary stability achievable with standard protocols

RY-II: Hybrid Cortico-Zygomatic Maxilla

In RY-II patients the front of the mouth still has serviceable bone — enough for two to four conventional fixtures — but the posterior zones have resorted to a point where routine implants are not viable. Rather than grafting, we supplement the anterior anchorage with selective zygomatic and/or pterygoid implants posteriorly, creating a hybrid construct that achieves the cross-arch rigidity needed for immediate loading.

- **CBCT Criteria:** Adequate anterior (Zone 1) bone, posterior (Zones 2–3) alveolar height <8 mm or width <5 mm, moderate sinus pneumatisation, pterygoid corridor accessible, zygomatic bone volume sufficient for single zygomatic implant
- **Implant Strategy:** Two to four conventional anterior implants combined with one zygomatic implant per side (bilateral) and/or pterygoid implants bilaterally
- **Immediate Loading:** Predictable when cross-arch rigidity is achieved through combined implant splinting

RY-III: Advanced Cortico-Zygomatic Maxilla

By the time patients reach the RY-III stage, posterior alveolar bone is essentially gone and bilateral zygomatic anchorage becomes the primary load-bearing structure. The sinuses are markedly enlarged on both sides, and any residual alveolar height in the anterior arch — even a few millimetres — must be pressed into service via pterygoid or nasal-floor-engaging implants. Available cortical structures become critical for achieving primary stability Figure 2.

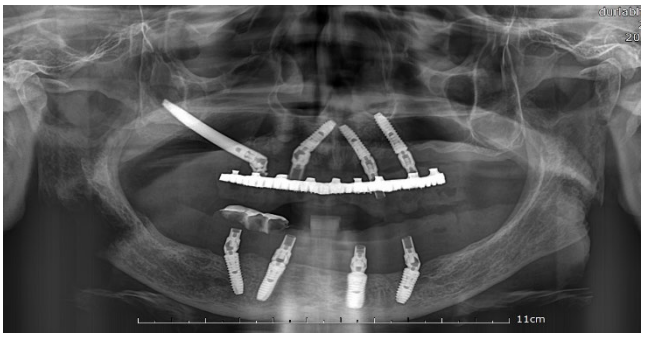


Figure 2: Post-Operative Panoramic Radiograph of an RY-II Patient Following Hybrid Rehabilitation: Conventional Anterior Implants Combined with A Unilateral Zygomatic Implant Providing Posterior Cortical Anchorage. Cross-Arch Splinting Achieves Rigid Fixation for Immediate Prosthetic Loading

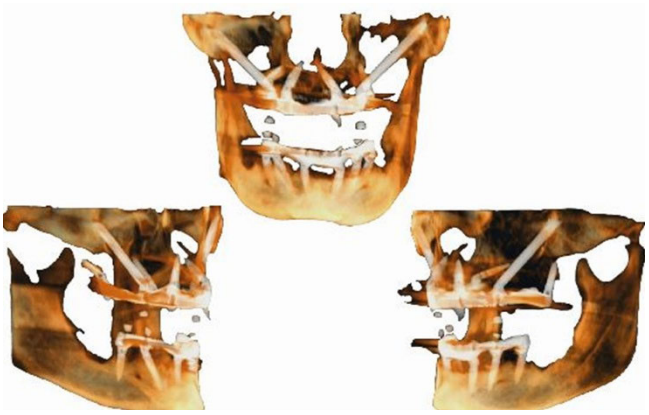


Figure 3: Pre-Operative CBCT Assessment of an RY-III Patient Displayed in Implant Planning Software. The Panoramic Reconstruction (Upper Panel) And Axial Cross-Sectional Slices (Lower Panel) Confirm Severe Bilateral Posterior Alveolar Atrophy with Marked Sinus Pneumatisation, Consistent with RY-III Classification Criteria. The Cross-Sectional Views Guide Implant Trajectory Planning for Bilateral Zygomatic Placement

- **CBCT Criteria:** Extensive posterior atrophy (Zones 2–3), anterior alveolar height 4–8 mm, severe bilateral sinus pneumatisation, bilateral zygomatic bone suitable for single zygomatic implant per side
- **Implant Strategy:** Bilateral single zygomatic implants combined with pterygoid implants and/or nasal-cortex-engaging anterior implants
- **Immediate Loading:** Achievable with rigid full-arch prosthetic splinting, biomechanical planning is critical

RY-IV: Extreme Atrophic Cortical Rescue Maxilla

RY-IV represents the most severe form of maxillary atrophy requiring complete cortical anchorage. Alveolar bone has all but disappeared, the sinuses have expanded to encroach on

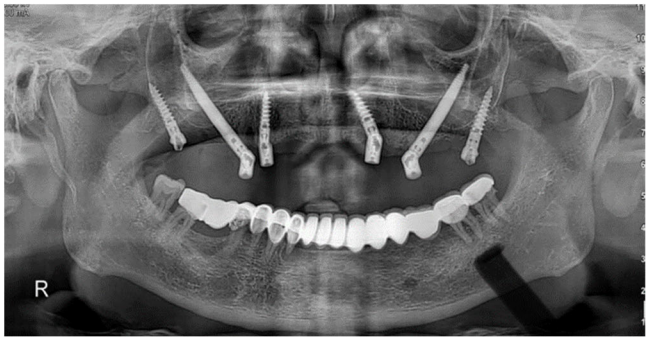


Figure 4: Post-Operative Panoramic Radiograph of an RY-III Patient (Case De-Identified) Demonstrating Bilateral Zygomatic Implants Supplemented by Pterygoid Implants. Bilateral Mandibular Implant-Supported Rehabilitation is Also Present. Note the Characteristic Angulation of the Zygomatic Implants Engaging the Zygomatic Body Above the Maxillary Sinus

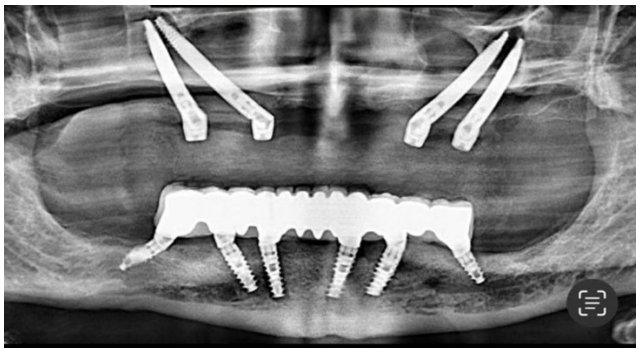


Figure 5: Three-Dimensional Colour CBCT Reconstruction (Frontal View) of an RY-IV Patient Demonstrating Near-Complete Maxillary Resorption and Bilateral Double Zygomatic (Quad-Zygomatic) Implant Configuration with Prosthetic Framework in Situ. Red Markers Indicate Mandibular Condylar Reference Landmarks. The Mandibular Arch Demonstrates Implant-Supported Prosthetic Rehabilitation

the premaxilla, and there is no residual ridge capable of contributing meaningful anchorage. The entire prosthetic load must be transferred through extra-alveolar cortical pillars, which in practice means a quad-zygomatic configuration — two fixtures per side — sometimes reinforced with pterygoid implants when the anatomy permits Figure 3-4.

- **CBCT Criteria:** Near-complete alveolar resorption (residual height <4 mm across all zones), bilateral maximal sinus pneumatisation, no functional anterior alveolar support, zygomatic bone sufficient for double zygomatic configuration per side
- **Implant Strategy:** Quad-zygomatic implants (two anterior + two posterior per side) with or without pterygoid implants, no conventional alveolar implants

Table 2: Comparison of the ZAGA and RY Cortico-Zygomatic Classification Systems

Feature	ZAGA Classification [11]	RY Cortico-Zygomatic Classification
Primary focus	Implant–sinus wall relationship at buttress	Arch-level cortical anchorage pattern
Scope	Site-specific (per implant)	Full arch (treatment planning)
Number of types	5 (ZAGA 0–4)	4 (RY-I to RY-IV)
CBCT parameters	Palato-buccal contour at buttress	Alveolar height/width, sinus, nasal, pterygoid, zygomatic bone
Prosthetic guidance	Indirect	Direct (prosthetically driven)
Scope of implant types	Zygomatic only	Conventional, pterygoid, zygomatic
Immediate loading guidance	Not primary focus	Integrated into classification criteria
Research utility	Surgical outcome stratification	Treatment planning + outcome stratification

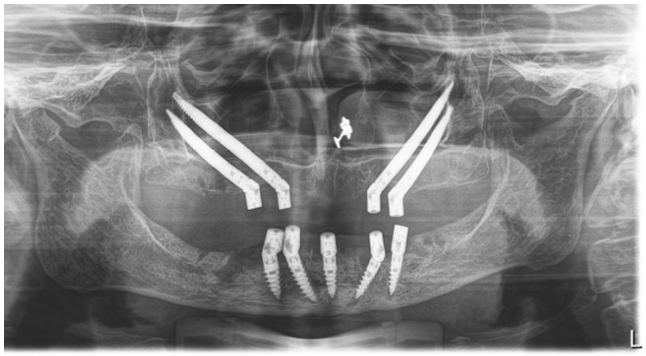


Figure 6. Panoramic Radiograph of a Second RY-IV Patient Illustrating the Characteristic Bilateral Quad-Zygomatic Implant Configuration with Full-Arch Cross-Arch Splinting. Absence of Posterior Maxillary Alveolar Support Is Radiographically Confirmed, Consistent with The Extreme Atrophic Cortical Rescue Classification

- **Immediate Loading:** Case-dependent, requires rigorous biomechanical evaluation, provisional prosthesis mandatory prior to definitive restoration

Comparison with the ZAGA Classification

The ZAGA classification [11] sorts the palato-buccal contour of the alveolar crest at the implant emergence zone into five types, ZAGA 0 through 4 [11-12]. This classification solely focuses on how the implant relates to the maxillary sinus wall at the buttress, hence, it works as a guide for surgical trajectory rather than a classification for arch-level treatment planning. The new RY Classification instead operates at the arch level, grouping patients by the pattern of cortical anchorage required for full prosthetic rehabilitation. The two systems work together: RY describes which implant types and configurations are needed, whereas ZAGA helps guide the trajectory of each individual zygomatic implant. Table 2 lists the main differences between them Figure 5-6.

METHODS

Study Design and Ethical Approval

This retrospective cohort study drew on data from two referral centres with experience in graftless maxillary rehabilitation. Surgeries took place between February 2020 and February 2023, and patients were followed until February 2026, giving a minimum follow-up of 36 months. The study adhered to the principles of the Declaration of Helsinki (2013 revision). Written informed consent was obtained from each patient before enrolment, and the study is reported according to STROBE guidelines for observational research.

Inclusion and Exclusion Criteria

Patients qualified for inclusion if they were systemically healthy or had well-controlled systemic disease (ASA I or II), were fully edentulous in the maxillary arch, or needed full clearance followed by immediate rehabilitation, had a pre-operative CBCT scan of diagnostic quality (≤0.25 mm voxel size), fit one of the four RY categories, and received an immediately loaded provisional prosthesis within 3–7 days of surgery. Exclusion criteria were: uncontrolled systemic disease, active intraoral infection, head-and-neck irradiation within the previous five years, intravenous bisphosphonate therapy, active smoking of more than 20 cigarettes a day, or CBCT data insufficient for classification.

Pre-Operative CBCT Protocol and RY Classification

All patients underwent pre-operative CBCT assessment using Carestream CS Imaging Software. Residual alveolar bone, maxillary sinus anatomy, cortical bone availability, and implant trajectory were evaluated. Each case was allocated to one of the four RY categories based on these findings, which directly informed implant selection and strategy for rehabilitation. Classification was performed independently by two experienced oral and maxillofacial surgeons, disagreements between them were resolved by consensus with a third senior assessor. Interobserver agreement was quantified using the Cohen's kappa (κ) statistic.

Surgical Technique

All procedures were performed under local anaesthesia alone, with the agent, volume, and infiltration technique adapted to each patient's anatomical presentation, systemic condition, and the precautions mandated by the extent of the planned surgery. Only surgeons with a documented history of more than 50 zygomatic implant cases were permitted to operate. Access was achieved through a crestal incision extended with bilateral vertical releases at the zygomatic buttress, followed by elevation of a full-thickness mucoperiosteal flap to expose the zygomatic body. Zygomatic fixtures were placed freehand under digital pre-operative guidance, using the Quickdent Zygomatic Implant System (Quickdent International) exclusively, no other zygomatic implant system was used in this series. At each zygomatic implant site, the

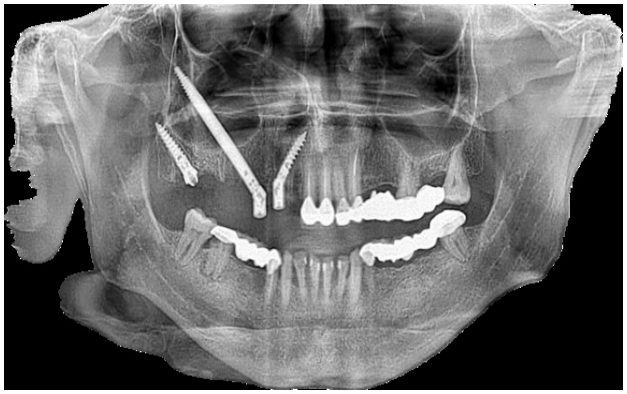


Figure 7: Intra-Operative Panoramic Radiograph Demonstrating Implant Placement During an RY-II Hybrid Rehabilitation Procedure. A Zygomatic Implant is Visible on the Left Side Engaging the Zygomatic Body, with Anterior Conventional Implants Providing Premaxillary Support. This Image Illustrates the Intra-Operative Verification of Implant Positioning Prior to Prosthetic Abutment Selection

trajectory was individually selected according to ZAGA type. A minimum insertion torque of 35 Ncm was required before any implant was retained, primary stability was then quantified with Osstell resonance frequency analysis. Conventional and pterygoid fixtures were likewise placed using the Quickdent Dental Implant System, following standard drilling sequences for conventional sites and trajectories directed to engage the pterygoid plates and pyramidal process for pterygoid sites. Co-amoxiclav 1.2 g was given intravenously at induction and continued orally for five days post-operatively.

Prosthetic Protocol

Open-tray impressions or digital scans were obtained intra-operatively. Provisional full-arch prostheses, fabricated in PMMA (polymethyl methacrylate) or as a hybrid acrylic-metal framework according to case-specific biomechanical requirements, were splinted across all implants and delivered within 3–7 days, the exact timing being individualised to primary stability, occlusal load-bearing considerations, and RY category. Patients were maintained on a soft diet for 12 weeks. Definitive prostheses (screw-retained, milled zirconia or hybrid ceramic frameworks) were delivered at 6–9 months after implant placement, once osseointegration had been confirmed Figure 7.

Follow-Up and Outcome Assessment

Review appointments were scheduled at one week, one month, three months, six months, one year, two years, and three years. The primary endpoint was cumulative implant survival at 36 months, an implant was counted as a failure if it showed mobility, unresolvable infection, persistent pain or altered sensation, or a peri-implant radiolucency. The modified Albrektsson success criteria (1986, updated 2015) were applied as a stricter threshold. Secondary outcomes comprised marginal bone loss measured on standardised intraoral periapical radiographs at baseline, 12 months, and 36 months, ISQ recorded at implant placement and again at six months, sinus-related adverse events, prosthetic complications, and OHIP-14 scores collected at baseline, 12 months, and 36 months.

Statistical Analysis

IBM SPSS Statistics v26.0 software was used to analyse the data. Continuous variables are presented as mean±SD and categorical variables as frequency (%). Kaplan-Meier survival curves and log-rank tests were used to compare survival between groups. Marginal bone loss comparisons used repeated-measures ANOVA with Bonferroni post-hoc correction. OHIP-14 scores were compared using the Wilcoxon signed-rank test. Interobserver agreement was evaluated with Cohen's kappa. Statistical significance was set at $p<0.05$.

RESULTS

Denominator and follow-up audit: Of 369 reported implants, 11 were recorded as lost, yielding 358/369 = 97.0% crude implant retention. Within RY-IV, 183/191 = 95.8% (one-decimal rounding), not 95.9%. Crude proportions should not be termed Kaplan–Meier survival without documented event times and censoring. Implant-level events are clustered within 77 patients, and patient-level analyses and follow-up completeness should be reported before claims of category-specific prognostic validity.

Patient Demographics and Classification Distribution

Seventy-seven patients (42 males, 35 females, mean age 56.3±8.7 years, range 38–72 years) met the inclusion criteria. Twelve had well-controlled type 2 diabetes mellitus (HbA1c <7.5%) and 18 had pharmacologically managed hypertension. Fourteen were former smokers (cessation more than 12 months pre-operatively). Classification distribution was as follows: RY-I (n = 8, 10.4%), RY-II (n = 15, 19.5%), RY-III (n=22, 28.6%), RY-IV (n = 32, 41.5%). Interobserver agreement for RY classification was excellent ($\kappa = 0.91$, 95% CI 0.85–0.97) as given in Table 3 and Figure 8-9.

Implant Data

A total of 369 implants were placed: 102 conventional implants, 67 pterygoid implants, and 200 zygomatic implants. Mean zygomatic implant length was 42.3±4.8 mm (range 35–52.5 mm). Mean insertion torque was 62.4±9.1 Ncm for zygomatic implants and 34.7±6.8 Ncm for conventional implants. Table 4 depicts implant distribution and ISQ values by RY category Table 4.

Implant Survival

Eleven of 369 implants were reported lost (358/369 retained, 97.0%). Tabulated category totals indicate 1/60 losses in RY-II, 2/86 in RY-III and 8/191 in RY-IV, with none in RY-I. The RY-IV crude retained fraction is 183/191 = 95.8%, not 95.9% Table 5.

Table 3: Patient Demographics and Classification Distribution (N=77)

Variable	RY-I (n = 8)	RY-II (n = 15)	RY-III (n = 22)	RY-IV (n = 32)	Total (n = 77)
Male / Female	5 / 3	9 / 6	13 / 9	15 / 17	42 / 35
Age, mean±SD (years)	54.1±7.2	55.8±8.1	56.9±8.4	57.1±9.3	56.3±8.7
Diabetes mellitus (n)	0	2	4	6	12
Hypertension (n)	1	3	6	8	18
Former smoker (n)	1	2	4	7	14
Follow-up, mean (months)	38.6	37.8	37.2	36.9	37.5

Table 4: Implant Distribution and Stability (ISQ) by RY Classification Category

RY Category	Conv. (n)	Pterygoid (n)	Zygomatic (n)	Total	ISQ at Placement	ISQ at 6 months
RY-I	32	0	0	32	71.8±3.2	78.4±2.8
RY-II	30	15	15	60	68.4±4.1	75.2±3.6
RY-III	20	22	44	86	65.1±5.3	72.7±4.5
RY-IV	20	30	141	191	63.6±6.4	70.9±5.7
Total	102	67	200	369	65.9±5.8	73.4±4.9

Table 5: Implant Survival Rates at 12 and 36 Months According to the RY Classification

RY Category	Implants Placed	Implants Lost	ISR at 12m (%)	ISR at 36m (%)
RY-I	32	0	100.0	100.0
RY-II	60	1	98.3	98.3
RY-III	86	2	97.7	97.7
RY-IV	191	8	95.8	95.8
Total	369	11	97.0	97.0

Table 6: Mean Marginal Bone Loss (mm±SD) at 12 and 36 Months by RY Category

RY Category	MBL at 12m (mm±SD)	MBL at 36m (mm±SD)
RY-I	0.18±0.09	0.31±0.12
RY-II	0.29±0.14	0.48±0.18
RY-III	0.41±0.18	0.67±0.22
RY-IV	0.57±0.24	0.89±0.31

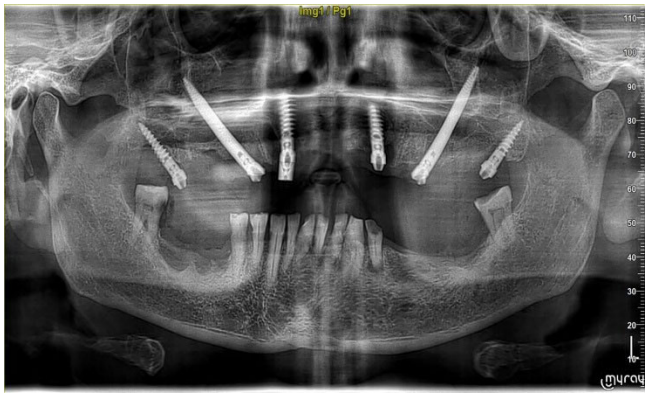


Figure 8: Panoramic Radiograph of a Representative RY-III Patient at 12-Month Review Demonstrating Bilateral Zygomatic Implants with Definitive Screw-Retained Full-Arch Prosthesis. Stable Peri-Implant Bone Levels Are Evident at The Zygomatic Implant–Abutment Interface. Mandibular Natural Dentition Serves as The Opposing Arch

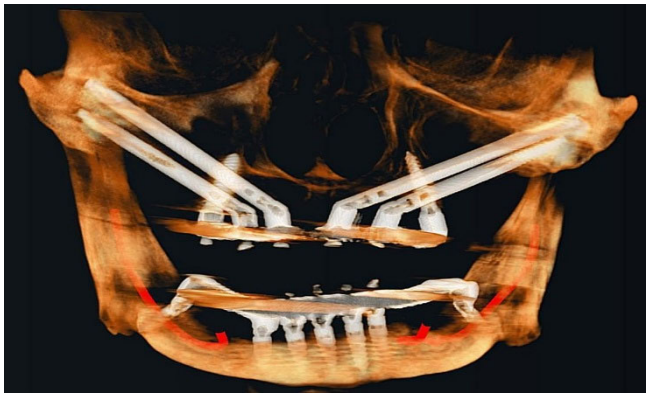


Figure 9: Panoramic Radiograph of a Second RY-IV Patient at 36-Month Follow-Up Confirming Bilateral Zygomatic Implant Osseointegration and Stable Marginal Bone Levels. The Full-Arch Implant-Supported Prosthesis Shows No Evidence of Prosthetic Fracture or Component Failure at Three-Year Review

Marginal Bone Loss

Bone remodelling at the implant neck remained within accepted clinical limits: no category exceeded 1.0 mm of mean marginal bone loss at three years. That said, the gradient across categories was real and statistically significant — RY-IV patients lost more crestal bone than RY-I patients at both the one-year ($p = 0.03$) and three-year ($p = 0.01$) time points, almost certainly because more prosthetic load is concentrated on each fixture when the total implant count is lower. The gradient was not confined to the two extremes: RY-II and RY-III patients also showed measurable marginal bone loss, intermediate between the RY-I and RY-IV figures, consistent with a progressive rather than a stepwise relationship between cortical anchorage category and crestal remodelling. A further contributing factor in the RY-IV group was the greater extent of soft-

Table 7: Mean OHIP-14 Scores by RY Category and Follow-Up Time-Point

RY Category	Pre-operative	12 Months	36 Months	% Improvement
RY-I	28.4±5.1	10.2±3.1	7.1±2.4	75.0%
RY-II	34.6±6.3	11.8±3.6	8.3±2.9	76.0%
RY-III	39.8±6.9	13.4±4.1	8.9±3.2	77.6%
RY-IV	42.6±7.8	14.1±4.7	9.4±4.1	77.9%
Overall	38.4±7.2	12.8±4.1	8.6±3.4	77.6%

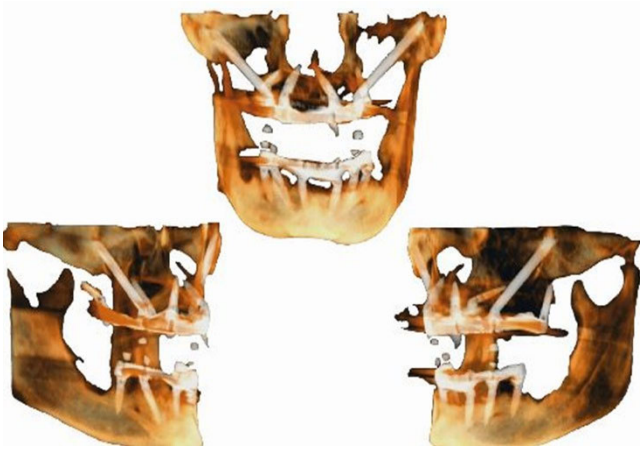


Figure 10: Pre-Operative CBCT Assessment Panel of an Additional RY-III Patient. The Panoramic Scout Image (Top) Confirms Complete Maxillary Edentulism with Near-Total Alveolar Resorption. Sequential Cross-Sectional Slices (Bottom, Highlighted Region) Demonstrate the Absence of Posterior Alveolar Bone and Massive Bilateral Sinus Pneumatisation, Confirming the Need for Quad-Zygomatic Cortical Rescue Rehabilitation

tissue resection required at surgery — the infrazygomatic dissection and flap management needed to accommodate a quad-zygomatic configuration routinely involved more extensive excision of redundant or compromised peri-implant soft tissue than in the lower RY categories, and this more extensive local tissue handling likely compounded the mechanical load effect on crestal bone levels in this group. All values are given in Table 6.

Complications

Sinus-related events occurred in nine patients (11.7%), all within the RY-III or RY-IV groups. Six patients (7.8%) developed transient post-operative sinusitis, which resolved with saline irrigation, topical decongestants, and a brief course of antibiotics, none required implant removal. Two patients (2.6%) presented with oro-antral communications at extraction sockets, which were closed with local flaps before implant placement and healed without further difficulty. A single RY-IV patient (1.3%) developed a cheek fistula at six months, conservative debridement and wound revision resolved the problem without affecting the prosthesis. On the prosthetic side, three patients (3.9%) experienced resin tooth fractures and five (6.5%) had screw loosening — all addressed at routine maintenance visits. Encouragingly, not a single patient developed persistent paraesthesia or osteonecrosis over the follow-up period.

Patient-Reported Outcomes (OHIP-14)

OHIP-14 scores demonstrated a statistically significant and clinically meaningful improvement at all follow-up time-points. Pre-operative mean OHIP-14 was 38.4±7.2. At 36 months, mean OHIP-14 was 8.6±3.4, representing a 77.6% reduction ($p<0.001$). Improvements were consistent across all RY categories. Table 7 details OHIP-14 scores by category and time-point Figure 10.

CONCLUSIONS

The present study introduces and provides the first clinical validation of the RY Cortico-Zygomatic Classification, a four-tier CBCT-based system designed to guide prosthetically driven implant treatment planning across the full spectrum of maxillary atrophy. The high inter-observer agreement ($\kappa=0.91$) confirms the system's reproducibility, and 36-month outcomes compare favourably with published benchmarks for zygomatic implant therapy.

The reported crude implant retention was 97.0% overall at 36 months, with 95.8% in RY-IV compared with 100% in RY-I. Differences between anatomical categories cannot be attributed to their classification or presumed loading mechanics without adjustment for case mix, implant clustering and follow-up patterns.

Marginal bone loss remained below the thresholds Albrektsson *et al.* [17] defined as acceptable across every RY category. The steady climb in MBL — from 0.31 mm in RY-I to 0.89 mm in RY-IV at three years — most probably reflects a straightforward mechanical reality: in higher-category patients, a smaller number of implants must distribute the same prosthetic load, increasing stress at each fixture-bone interface. These findings suggest that rigid cross-arch splinting and careful framework design are important biomechanical considerations in RY-III and RY-IV rehabilitation.

The relationship between RY and ZAGA is one of complementarity rather than competition. ZAGA [11] answers a site-specific surgical question: given this palato-buccal contour at a single zygomatic buttress, which implant trajectory minimises sinus complications? RY addresses a different, arch-level question: given the patient's overall atrophy pattern, what combination of implant types and anchoring strategies is required? RY indicates whether zygomatic implants are needed at all (RY-I: no), used in a hybrid arrangement (RY-II), placed bilaterally as singles (RY-III), or arranged in a quad configuration (RY-IV).

Yadav *et al.* [16] made a meaningful contribution by establishing that Quickdent zygomatic implants perform reliably in the Indian clinical setting. Our work takes that foundation a step further: by prospectively applying a

standardised classification, we can now compare outcomes across patient subgroups defined by atrophy severity rather than treating the population as homogeneous.

A sinus complication rate of 11.7% sits within the 8–14% range widely quoted in the zygomatic literature [18-19], and the fact that every case resolved without implant loss suggests that ZAGA-guided trajectories are indeed reducing the clinical impact of sinus events. The single cheek fistula in an RY-IV patient (1.3% of that subgroup) is a recognised, if uncommon, consequence of infrazygomatic soft-tissue dissection [21] and should not be overlooked in pre-operative counselling for this category. On the quality-of-life side, a 77.6% fall in OHIP-14 score — consistent across all four categories — reinforces the robust and durable patient-centred benefit that full-arch implant rehabilitation delivers**,** regardless of where a patient sit on the atrophy spectrum [21-23].

We acknowledge several limitations. Retrospective data collection at just two centres constrains generalisability, and although 77 patients are sufficient to describe the classification and report early outcomes, the numbers are too small for robust subgroup analyses. Whether clinicians earlier in their learning curve can apply the RY criteria with the same reliability as experienced zygomatic surgeons is a question that prospective multicentre work will need to answer. Follow-up to 36 months is encouraging but, given the decades-long service life expected of these prostheses, longer observation is clearly needed.

CONCLUSION

This retrospective experience describes four proposed RY anatomical categories and crude implant retention of 358/369 implants over the reported follow-up. It does not independently validate the classification, establish superiority over ZAGA or other planning frameworks, or show that the classification caused the observed outcomes. Future multicentre research should test category assignment reliability, prognostic discrimination, patient-level clustering and clinical decision impact.

Across 77 consecutively treated patients followed for at least three years, we recorded an overall implant survival rate of 97.0%, marginal bone levels that remained within accepted limits in every category, and a 77.6% reduction in OHIP-14 scores from baseline to 36 months. Taken together, these figures indicate that guiding rehabilitation decisions through the RY framework produces strong functional results and meaningful quality-of-life gains at every level of atrophy severity.

When used alongside the ZAGA classification, which determines how each individual zygomatic implant is placed, the RY Classification addresses the upstream question of which implant types and arch configuration are required. Multicentre prospective studies are needed in the near future to confirm the reproducibility of these findings across different clinical settings and to assess long-term outcomes beyond the current three-year horizon.

DECLARATIONS

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Conflicts of Interest

No conflict of interest was reported by any of the authors.

Ethics Approval

Conducted in accordance with the Declaration of Helsinki.

Data Availability

Data are available from the corresponding author on reasonable request.

Author Contributions

All authors contributed to study conception, data collection, and manuscript preparation and approved the final manuscript.

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