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ORIGINAL RESEARCH

Comparative Evaluation of Four Multiple Allergen Simultaneous Test (MAST) Systems in Clinical Practice

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Purpose: Multiple allergen simultaneous tests (MASTs) are widely used for screening allergen-specific immunoglobulin E owing to their convenience and cost-effectiveness. Recently, several automated MAST analyzers with expanded allergen panels have become available in Korea; however, comparative evaluations remain limited.

Patients and Methods: In this retrospective study, 200 residual serum samples from patients tested for suspected allergic diseases at a single tertiary hospital were analyzed. Each sample was tested using AdvanSure Alloscreen, AdvanSure Alloscreen Max108, SGTi-Allergy Screen, and PROTIA Allergy-Q. Semi-quantitative results (classes 0–6) were interpreted as positive at class ≥2. Concordance rates and Cohen's kappa coefficients were calculated.

Results: Overall agreement between the MAST systems was high (91–93%), with Cohen's kappa values indicating substantial to almost perfect agreement (κ = 0.67–0.76). The agreement between AdvanSure Alloscreen and its upgraded version, AdvanSure AlloScreen Max108, was the highest. For common allergens in the Korean population, *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae* showed moderate agreement (κ = 0.47–0.82, respectively) between the MAST systems. Re-testing of discrepant samples (n = 78; 31 allergens) using ImmunoCAP—often considered the gold standard for allergy testing—demonstrated the highest concordance for the SGTi Allergy Screen (76.39%).

Conclusion: All four MAST systems demonstrated substantial to near-perfect qualitative agreement. The SGTi-Allergy Screen showed the best concordance with ImmunoCAP, whereas AdvanSure Alloscreen Max108 offered a balanced performance with broader allergen coverage. These findings indicate that laboratories should select a MAST system based on local needs, weighing analytical accuracy, allergen panel breadth, and overall testing efficiency.

Plain Language Summary: Allergies are becoming more common around the world, and laboratory tests are commonly used to support the evaluation of allergic sensitization in clinical practice. One of these tests is called the Multiple Allergen Simultaneous Test (MAST), which can detect antibodies in the blood that react to many different allergens at once. Because several different MAST systems are used in clinical practice, it is important to understand how similar their results are and how they compare with one another.

In this study, we compared four commonly used MAST systems by testing blood samples for common airborne and food allergens, such as house dust mites, pollen, and nuts. We examined how closely the test results agreed across systems and rechecked some inconsistent results using another laboratory method called ImmunoCAP, which is often used as a reference test.

We found that the four MAST systems produced broadly similar results overall, although differences were observed for certain plant-based allergens. Among the systems, the SGTi-Allergy Screen showed the closest agreement with the reference test, while the AdvanSure Alloscreen Max108 offered a wider range of allergens in a single test.

These findings can help clinicians better understand the strengths of each system and make informed choices when selecting a MAST system for routine testing.

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Introduction

The number of people diagnosed with allergic diseases has been steadily increasing as modern environmental exposures evolve.[1] In clinical practice, the diagnosis of allergies relies heavily on patient-reported symptoms, medical history, and physical examination findings to identify potential causative agents. To assess Immunoglobulin E sensitization, allergen-specific Immunoglobulin E (sIgE) levels can be measured using both in vivo and in vitro methods. Skin prick testing has traditionally been used, but may be limited in patients who cannot discontinue antihistamines or who have dermatologic conditions, and positive results may also occur in individuals without clinically relevant allergy.[2] In vitro sIgE assays provide complementary information to skin testing and are widely used as screening tools for sensitization in clinical practice.[3]

Among the commercially available in vitro methods, multiple allergen simultaneous tests (MASTs) require only a small volume of serum, offer short processing times, and continue to evolve by expanding the allergen spectrum included in each panel.[4] The prevalence and spectrum of allergic sensitization vary according to region, age, and ethnicity, underscoring the importance of selecting an appropriate MAST panel based on the characteristics of the target population. However, differences in allergen sources, extraction methods, solid-phase attachment techniques, and detection technologies mean that no single analytical method has yet been universally accepted as a reference standard.[5]

In this context, a comparative evaluation of different MAST systems is clinically meaningful, as it provides evidence regarding their analytical agreement, diagnostic reliability, and coverage of clinically relevant allergens. Such assessments can guide laboratories in selecting the most appropriate system for their local patient populations and national healthcare needs. In this retrospective study, we compared the diagnostic performances of four fully automated MAST analyzers commonly used in Korea.

Materials and Methods

Study Participants

From November 2023 to December 2023, 200 residual serum samples were randomly collected from patients who underwent inhalant or food MAST panel testing for suspected allergic diseases at a single tertiary hospital. This study was approved by the Institutional Review Board of Severance Hospital (IRB No. 2023–3201-002).

In vitro sIgE Measurements

All serum samples were first tested using AdvanSure Alloscreen (Invitros, Cheongju-si, Korea), which served as the institutional reference method. Residual serum aliquots were subsequently analyzed on the same day using three additional systems: AdvanSure Alloscreen Max108 (Invitros, Cheongju-si, Korea), SGTi-allergy screen (Sugentech, Cheongju-si, Korea), and PROTIA allergy-Q (Protia, Seoul, Korea). All assays were performed according to the manufacturer's instructions. The results were expressed on a semi-quantitative scale ranging from class 0 to 6 for all analyzers. The detailed technical specifications of each MAST system are listed in Table 1. For discrepant cases with sufficient residual serum, additional testing was performed using ImmunoCAP (Phadia AB, Uppsala, Sweden), which is considered the gold standard for sIgE measurements. A complete list of the allergens included in each panel is provided in Table S1.

Statistical Analysis

Allergens were pre-specified into eight groups: dust, animal epithelium, weed, mold, tree, grass, insects, and food. The results from the AdvanSure Alloscreen served as the institutional reference for comparison, whereas ImmunoCAP results, when available, were considered the true reference standard.[6] For allergens not included in the AdvanSure Alloscreen assay, concordant results across other assays were used as surrogate reference standards. Following Rim et al,[4] positivity was defined as class ≥2 Pairwise analyses were restricted to 91 allergens shared across systems, while

Table 1 Technical Specifications and Distinguishing Features of the Four MAST Systems Evaluated

	AdvanSure Alloscreen	AdvanSure Alloscreen Max108	SGTi-Allergy Screen	Protia Allergy-Q
Manufacturer	Invitros, Cheongju-si, Korea	Invitros, Cheongju-si, Korea	Sugentech, Cheongju-si, Korea	Protia, Seoul, Korea
Instrument	AdvanSure AlloStation SMARTII	AdvanSure AlloView 2.0	S-Blot 3 PLUS	Q-STATION ELITE
Reagent panel	AdvanSure AlloScreen MAX panel	AdvanSure AlloScreen Max108	SGTi-Allergy Screen PLUS	PROTIA Allergy-Q 128M
Analytical principle	Immunoblot	Immunoblot	Immunoblot	Immunoblot
Result reporting	Class 0–6	Class 0–6	Class 0–6	Class 0–6
Degree of automation	Full automation	Full automation	Full automation	Full automation
Number of allergens	93	108	120	118
Minimum serum volume (μL)	50	150	300	180
Throughput (tests per run)	30	60	60	40
Analysis time (hours)	4	4	3.5	3.3
Special antigens	Pupa, silk cocoon (O211)	Ragweed, false (w4), Mucor racemosus (m4), Silk worm (i8)	Mouse (e71), Rat (e73), Ragweed, false (w4), Sunflower seed (k84), Olive tree (t9), Almond (f20), Strawberry (f44), Lobster (f80), lamb (f88), Pistachio (f208), Pumpkin (f225), Pine nut (f253), Plaice (f254), Eggplant (f262), Oyster (f290)	Sunflower seed (k84), Olive tree (t9), Rye-grass (g5), Rye (f5), Almond (f20), Strawberry (f44), Lobster (f80), lamb (f88), Pine nut (f253),Plaice (f254), Eel (f264), Oyster (f290), Pupa, silk cocoon (f743)

Notes: The table summarizes key analytical characteristics of the four multiple allergen simultaneous test (MAST) systems, including manufacturer, instrument, reagent panel, analytical principle, reporting scale, degree of automation, total number of allergens, serum volume required (μL), throughput (tests per run), analysis time (hours), and special antigens present in the indicated system but absent from the AdvanSure Alloscreen 93-allergen panel. All data are based on the manufacturer's instructions.

allergens unique to a single system were excluded (Table S1). For the class discrepancy analyses, allergens with <5 paired observations were excluded a priori.

The total agreement percentage was calculated as follows.[7]

$$Total\ agreement(\%) = \frac{(total\ number\ of\ results - number\ of\ discrepancies)}{total\ number\ of\ results} \times 100$$

The agreement levels were categorized as almost perfect (90–100%), substantial (80–90%), moderate (70–80%), fair (60–70%), or poor (< 60%). Cohen's kappa (κ) coefficient was used to evaluate agreement between paired assays,[8] with values interpreted as almost perfect (0.8–1.0), substantial (0.6–0.8), moderate (0.4–0.6), fair (0.2–0.4), and poor (<0.2). All statistical analyses were performed using Microsoft Excel 2016 (Microsoft, Redmond, WA, USA).

Results

Study Population

The baseline characteristics of the study population are summarized in Table 2. A total of 200 residual serum samples were analyzed. Due to limited residual serum volume, the SGTi-Allergy Screen was performed on 186 samples, while the remaining three MAST systems were tested on all 200 samples. The median patient age was 21.5 years (range, 2–85 years). Among the 200 patients, 86 were pediatric patients (<18 years), including 54 males. Overall, males accounted for 121 of 200 (60.5%) patients.

Inter-System Agreement

Across all paired comparisons, the overall agreement among the MAST systems ranged from 91% to 93%, with Cohen's κ values between 0.67 and 0.76, indicating substantial to almost perfect agreement (Table 3). The highest agreement was

Table 2 Baseline Characteristics of the Study Population and Sample Overview

Variable	Value
Total serum samples, n	200
Age, median (range), years	21.5 (2–85)
Overall Sex Distribution	
Male, n (%)	121 (60.5)
Female, n (%)	79 (39.5)
Pediatric patients (<18 years), n (%)	86 (43.0)
Male pediatric patients, n (%)	54 (62.8)
Female pediatric patients, n (%)	32 (37.2)

Notes: Pediatric patients were defined as individuals younger than 18 years. Sex distribution did not differ significantly between pediatric and non-pediatric groups ($p > 0.05$).

observed between AdvanSure Alloscreen and AdvanSure Alloscreen Max108 (93% agreement, $\kappa = 0.76$). For prevalent inhalant allergens in Korea, *Dermatophagoides pteronyssinus* (d1) and *D. farinae* (d2) showed inter-system agreement of 72–90% and 82–93%, respectively, with corresponding κ values of 0.47–0.79 and 0.60–0.82 (Table 3).[9,10]

Semi-Quantitative Class Differences

Inter-assay evaluations limited to overlapping allergens showed absolute ordinal class discrepancies generally ≤2. The most pronounced divergences occurred in the following food allergen categories: citrus mix (f33) (AdvanSure Alloscreen vs. AdvanSure Alloscreen Max108, comparison 1) and mussel (f37) (SGTi-Allergy Screen vs. PROTIA Allergy-Q, comparison 4), each demonstrating a three-class deviation. Figure 1 presents the distribution of these class discrepancies. In addition, mango (f91) showed an average 2.5-class discrepancy in AdvanSure Alloscreen vs. SGTi-Allergy Screen (comparison 2) and SGTi-Allergy Screen vs. PROTIA Allergy-Q (comparison 4).

ImmunoCAP Verification of Discrepant Results

Discrepant samples with sufficient residual serum (n = 78; 31 allergens) underwent confirmatory testing using ImmunoCAP. Sensitization to clinically suspected allergens was verified in 56 of 78 (71.8%) patients. Agreement with ImmunoCAP varied across platforms: 51.9% for AdvanSure Alloscreen, 61.5% for AdvanSure Alloscreen Max108, 76.7% for SGTi-Allergy Screen (highest), and 50.0% for PROTIA Allergy-Q (lowest) (Table 4). For *D. pteronyssinus* (n = 10), agreement reached 100% for the SGTi-Allergy Screen, and the concordant positive rate was markedly higher for the SGTi-Allergy Screen (92.9%), highlighting its superior alignment with ImmunoCAP.

Discussion

This single-center retrospective study demonstrated substantial to almost perfect qualitative agreement among four fully automated MAST platforms, with the highest pairwise concordance observed between AdvanSure Alloscreen versus AdvanSure Alloscreen Max108. However, ImmunoCAP verification of the discrepant cases revealed platform-specific differences. Notably, the SGTi-Allergy Screen showed the highest concordance with ImmunoCAP, whereas AdvanSure Alloscreen Max108 provided broader allergen coverage with comparable analytical reliability.

Inter-platform discordance likely reflects differences in antigen sources, extraction and coupling methods, solid-phase chemistry, calibration and class-mapping algorithms, and interference control (eg, cross-reactive carbohydrate determinants, PR-10 proteins). Differences in panel composition (mixed versus single extracts) may further influence class assignments, particularly for plant-derived foods. These assay-level factors are consistent with the larger class discrepancies observed for plant-based allergens (Figure 1) and the platform-specific ImmunoCAP concordance patterns (Table 4).

Our ImmunoCAP concordance was lower than that reported in previous studies.[11–13] This can be explained by the design limitations, including partial verification confined to discrepant cases, limited residual serum volume, and small numbers of

Table 3 Pairwise Agreement and Cohen's Kappa Values for Representative Inhalant and Food Allergens Across Four MAST Systems

Allergy Category	Allergen	Code	AdvanSure Alloscreen vs AdvanSure Alloscreen Max108		AdvanSure Alloscreen vs SGTi-Allergy Screen		AdvanSure Alloscreen vs Protia Allergy-Q		SGTi-Allergy Screen vs Protia Allergy-Q		SGTi-Allergy Screen vs AdvanSure Alloscreen Max108		Protia Allergy-Q vs AdvanSure Alloscreen Max108	
			A	κ	A	κ	A	κ	A	κ	A	κ	A	κ
Dust	House dust	h1	0.70	0.38	0.80	0.45	0.78	0.47	0.78	0.50	0.77	0.54	0.74	0.47
	Dermatophagoides pteronyssinus	d1	0.72	0.47	0.90	0.79	0.85	0.69	0.82	0.62	0.69	0.44	0.72	0.45
	Dermatophagoides farinae	d2	0.91	0.78	0.93	0.82	0.87	0.69	0.82	0.60	0.90	0.77	0.86	0.68
Animal Epithelium	Cat	e1/ex102	0.94	0.87	0.91	0.81	0.90	0.79	0.97	0.94	0.94	0.87	0.93	0.86
	Dog	e2/e5	0.97	0.93	0.92	0.82	0.96	0.90	0.96	0.90	0.94	0.85	0.97	0.93
Weed	Ragweed, short	w1/w2	0.92	0.72	0.91	0.70	0.93	0.68	0.89	0.60	0.91	0.74	0.86	0.48
	Mugwort	w6	0.94	0.77	0.92	0.71	0.95	0.76	0.92	0.71	0.93	0.77	0.94	0.74
Mold	*Alternaria alternata*	m6	0.96	0.83	0.96	0.84	0.93	0.73	0.94	0.75	0.92	0.71	0.94	0.76
Tree	Alder	t2	0.95	0.81	0.84	0.53	0.81	0.49	0.89	0.75	0.85	0.58	0.82	0.53
	Birch	t3	0.95	0.87	0.87	0.69	0.91	0.79	0.92	0.83	0.87	0.69	0.89	0.73
	Oak white	t7	0.92	0.82	0.85	0.67	0.78	0.46	0.82	0.52	0.89	0.75	0.81	0.51
Grass	Bermuda grass	g2	0.95	0.87	0.91	0.76	0.89	0.68	0.92	0.74	0.94	0.85	0.87	0.62
	Rye pollens	g12	0.96	0.90	0.87	0.60	0.87	0.56	0.95	0.75	0.83	0.52	0.83	0.48
Food	Egg white	f1	0.89	0.52	0.91	0.36	0.94	0.52	0.91	0.34	0.85	0.35	0.87	0.39
	Milk	f2	0.95	0.36	0.83	0.14	0.85	0.14	0.87	0.56	0.85	0.33	0.84	0.23
	Wheat flour	f4	0.95	0.77	0.92	0.63	0.92	0.65	0.94	0.65	0.94	0.65	0.94	0.68
	Buck-wheat	f11	0.95	0.71	0.90	0.54	0.97	0.78	0.91	0.52	0.90	0.55	0.96	0.72
	Peanut	f13	0.97	0.84	0.90	0.29	0.97	0.81	0.92	0.32	0.88	0.22	0.93	0.61
	Crab	f23	0.95	0.43	0.96	0.64	0.98	0.77	0.98	0.83	0.97	0.56	0.98	0.60
	Shrimp	f24	0.95	0.60	0.92	0.55	0.91	0.52	0.93	0.63	0.96	0.67	0.93	0.48
	Apple	f49	0.87	0.70	0.89	0.75	0.91	0.80	0.90	0.77	0.91	0.78	0.91	0.77
	Peach	f95	0.86	0.65	0.88	0.73	0.92	0.82	0.88	0.73	0.83	0.60	0.83	0.60
	Walnut	f256	0.92	0.66	0.90	0.55	0.93	0.54	0.89	0.55	0.90	0.65	0.94	0.68

Notes: Table 3 compares allergen-specific IgE reactivity results for representative inhalant and food allergens across AdvanSure Alloscreen, AdvanSure Alloscreen Max108, SGTi-allergy screen, and Protia allergy-Q (multiple allergen simultaneous test) MAST systems. Representative allergens were selected for their clinical relevance or high prevalence among Korean patients. For each allergen, overall agreement (A) and Cohen's κ are shown. Full datasets—including number of samples, concordant positives, overall agreement (%), and Cohen's κ with 95% confidence intervals—are provided in Table S2.

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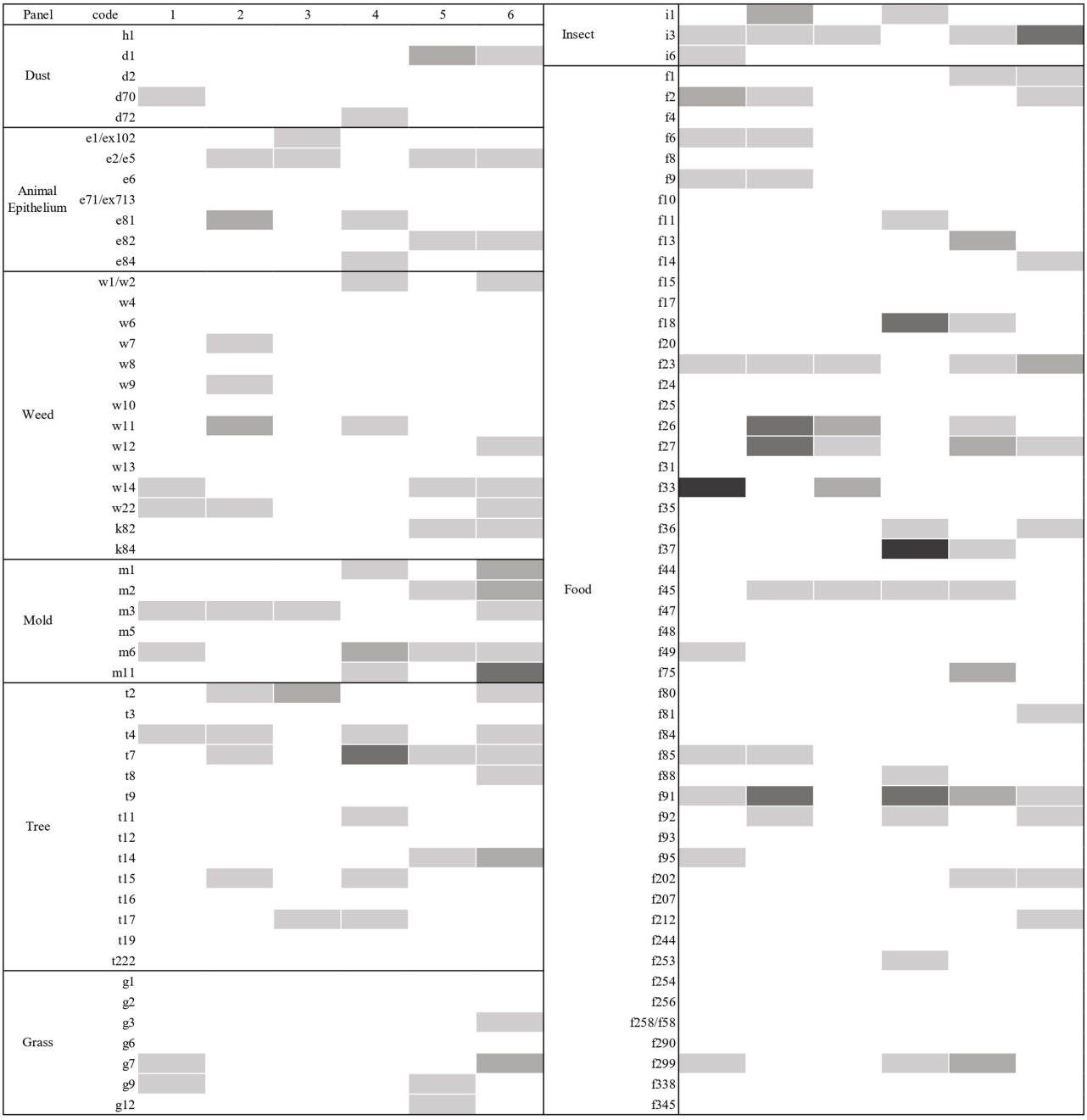

Figure 1 Heatmap of class difference between MAST systems. Heat map showing absolute semi-quantitative class differences between paired multiple allergen simultaneous test (MAST) systems for overlapping allergens. Rows represent individual allergens, grouped by allergen category (dust, animal epithelium, weed, mold, tree, grass, and food), and columns represent pairwise system comparisons. Allergen codes correspond to the WHO/IUIS allergen nomenclature and are detailed in Table S1. Shading was applied only when class differences exceeded 1, with the color intensity increasing in 0.5-class increments; darker shading indicated larger discrepancies. White cells indicate class differences ≤1 or identical class results. Column headers (1–6) correspond to: 1. AdvanSure Alloscreen vs. AdvanSure Alloscreen Max108; 2. AdvanSure Alloscreen vs. SGTi-allergy screen; 3. AdvanSure Alloscreen vs. Protia allergy-Q; 4. SGTi-allergy screen vs Protia allergy-Q; 5. SGTi-allergy screen vs AdvanSure Alloscreen Max108; and 6. Protia allergy-Q vs AdvanSure Alloscreen Max108.

certain allergens. These factors may have underestimated the concordance. Nevertheless, comparative analyses reflect real-world laboratory practice, where full verification by ImmunoCAP is often impractical owing to cost and workload.

Our findings have practical implications for laboratory adoption and reporting. When alignment with ImmunoCAP is prioritized (eg, confirmatory pathways or component-resolved testing), the SGTi-Allergy Screen may be advantageous Conversely, when broader allergen coverage and operational efficiency are the primary considerations (for example, integrated

Table 4 Concordance with ImmunoCAP Across Four MAST Systems

Allergy Category	Allergen	Code	ImmunoCAP	AdvanSure Alloscreen		AdvanSure Alloscreen Max108		SGTi-Allergy Screen		Protia Allergy-Q	
			No of tested	A	CPR	A	CPR	A	CPR	A	CPR
Dust	House dust	h1	2	1	1	1	1	0.5	1	0.5	0
	Dermatophagoides pteronyssinus	d1	10	0.8	0.8	0.2	0.2	1	1	0.9	0.9
	Dermatophagoides farinae	d2	1	0	0	1	1	1	1	1	1
	Storage mite	d72	1	0	0	1	1	1	1	1	1
Animal Epithelium	Cat	e1/ex102	4	0.5	0	1	1	0.5	1	0.5	1
	Dog	e2/e5	2	0	0	1	1	1	1	1	1
Weed	Ragweed, short	w1/w2	1	1	1	1	1	1	1	0	0
	Oxeye daisy	w7	2	0.5	0.5	1	1	1	1	0	0
	Russian thistle	w11	1	1	1	1	1	1	1	0	0
	Japanese hop	w22	1	1	1	1	1	1	1	0	0
Mold	*Alternaria alternata*	m6	1	1	NA	1	NA	0	NA	0	NA
Tree	Alder	t2	3	0.67	0.5	0.67	0.5	0.67	1	0.67	1
	Birch	t3	5	0.2	0	0.4	0.25	0.8	1	1	1
	Hazel	t4	7	0.29	0.33	0.86	1	0.86	1	0.57	0.5
	Oak white	t7	5	0.6	0.6	0.8	0.8	1	1	0.2	0.2
	Sycamore mix	t11	1	0	0	0	0	1	1	0	0
	Pine	t16	2	1	1	0.5	0.5	0.5	0.5	0	0
Food	Egg white	f1	4	0.25	0	0.75	1	0.67	1	0.25	0
	Milk	f2	1	0	0	0	0	1	1	0	0
	Maize	f8	4	0.25	0	0.25	0	0.75	1	0.25	0.33
	Buck-wheat	f11	1	0	NA	1	NA	0	NA	0	NA
	Soy bean	f14	2	0.5	0	0.5	1	0	0	1	1
	Beef	f27	1	1	NA	1	NA	0	NA	0	NA
	Citrus mix	f33	1	1	1	1	1	0	0	1	1
	Apple	f49	1	0	0	0	0	0	0	0	0
	Kiwi	f84	1	1	NA	0	NA	NA	NA	0	NA
	Mango	f91	5	0.8	1	0.6	1	0.75	1	0.4	0
	Banana	f92	2	1	NA	1	NA	1	NA	0	NA
	Peach	f95	4	0.5	0.5	0.25	0.25	1	1	0.75	0.75
	Cucumber	f244	1	0	NA	1	NA	0	NA	0	NA
	Walnut	f256	1	0	NA	0	NA	NA	NA	1	NA
Total			78	0.519	0.436	0.615	0.589	0.767	0.929	0.500	0.554

Notes: Values represent the number of tested samples, overall agreement (A), and concordant positivity rates (CPR) for each allergen.
Abbreviation: NA, Not applicable due to absence of positive cases.

food-plus-inhalant panels, higher throughput, or minimal sample volume), the AdvanSure Alloscreen Max108 offers a balanced performance. It should be noted that MAST results reflect IgE sensitization and do not by themselves establish clinically relevant allergy; therefore, test results should be interpreted in conjunction with clinical history and symptoms.

This study has some limitations. It was a single-institution, retrospective study that relied on residual serum and applied ImmunoCAP only to discrepant cases, which introduces both spectrum and partial-verification biases. Not all allergens were represented equally, and within-run and between-run reproducibility as well as lot-to-lot variability were not evaluated. Future multicenter prospective studies with larger sample sizes and comprehensive ImmunoCAP verification are warranted to validate these findings and enhance inter-system harmonization, particularly for allergens represented by limited numbers of samples in the present study.

Conclusions

In summary, the four fully automated MAST platforms showed high qualitative concordance; however, platform-specific differences persisted. Laboratories should balance analytical performance, allergen coverage, and workflow requirements when selecting a system.

Abbreviations

MAST, Multiple Allergen Simultaneous Test; sIgE, Specific Immunoglobulin E; ImmunoCAP (Thermo Fisher Scientific, Uppsala, Sweden; commercial reference assay); κ, Cohen's kappa coefficient; CPR, Concordant Positivity Rate; PR-10, Pathogenesis-Related protein family 10.

Ethics Approval and Informed Consent

This study was approved by the Institutional Review Board of Severance Hospital (IRB 2023-3201-002). The requirement for informed consent was waived because the study used residual serum samples obtained during routine clinical testing, posed minimal risk to participants, and involved no additional procedures. All samples and data were anonymized prior to analysis, and no identifiable personal information was accessed. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Consent for Publication

Not applicable. This study does not include any identifiable images, videos, recordings, or personal data.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; have agreed on the journal to which the article has been submitted; reviewed and approved all versions of the article before submission, during revision, and the final version accepted for publication; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that Invitros (Cheongju-si, Korea), Sugentech (Cheongju-si, Korea), and Protia (Seoul, Korea) provided the assay reagents in this study. The authors declare no other conflicts of interest in this work.

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