J Korean Med Sci. 2018 Aug 13;33(33):e218
https://doi.org/10.3346/jkms.2018.33.e218
eISSN 1598-6357·pISSN 1011-8934

JKMS

Original Article

Immunology, Allergic Disorders & Rheumatology

Check for updates

Oral Allergy Syndrome in Birch Pollen-Sensitized Patients from a Korean University Hospital

Jung-Hyun Kim,[1,2,3] **Sae-Hoon Kim**,[1,2,3] **Heung-Woo Park**,[1,2] **Sang-Heon Cho**,[1,2] **and Yoon-Seok Chang**[1,2,3]

[1]Department of Internal Medicine, Seoul National University College of Medicine, Seoul, Korea
[2]Institute of Allergy and Clinical Immunology, Seoul National University Medical Research Center, Seoul, Korea
[3]Department of Internal Medicine, Seoul National University Bundang Hospital, Seongnam, Korea

OPEN ACCESS

Received: Feb 8, 2018
Accepted: Apr 4, 2018

Address for Correspondence:
Yoon-Seok Chang, MD, PhD
Department of Internal Medicine, Seoul National University Bundang Hospital, Seoul National University College of Medicine, 82 Gumi-ro, 173-beon-gil, Bundang-gu, Seongnam 13620, Republic of Korea.
E-mail: addchang@snu.ac.kr

ORCID iDs
Jung-Hyun Kim
https://orcid.org/0000-0002-5498-5170
Sae-Hoon Kim
https://orcid.org/0000-0002-2572-5302
Heung-Woo Park
https://orcid.org/0000-0002-6970-3228
Sang-Heon Cho
https://orcid.org/0000-0002-0841-9602
Yoon-Seok Chang
https://orcid.org/0000-0003-3157-0447

Disclosure
The authors have no potential conflicts of interest to disclose.

ABSTRACT

Background: Oral allergy syndrome (OAS) is a type of allergic reaction that mainly occurs on oral contact with raw fruit, vegetables, or nuts. The most common type of OAS is birch pollen-related food allergy. Although OAS is a common food allergy in adults, only few epidemiologic studies have been reported in Korea. Here we investigate the prevalence and triggers of birch pollen-related food allergy.
Methods: We conducted a retrospective chart review of 1,427 patients who underwent a skin prick test for inhalant allergens at the Asthma and Allergy Clinic in Seoul National University Bundang Hospital from January 2011 to December 2016.
Results: Of 1,427 patients, 125 (8.7%) were sensitized to birch pollen. Among them, 20.0% developed OAS, which was the most common food allergy (96.2%). The prevalence of OAS was higher in females, and was 18.2% in birch pollen-sensitized allergic rhinoconjunctivitis patients. Further, 72.0% OAS patients had rhinoconjunctivitis, 20.0% had asthma, and 12.0% had chronic urticaria. Apple (68.0%), peach (56.0%), nuts (36.0%), kiwi (20.0%), persimmon (20.0%), plum (16.0%), and cherry (16.0%) were frequent triggers; however, Chinese yam, kudzu vine, bellflower root, codonopsis, and ginseng were also revealed as triggers. Patients (60.0%) showed OAS with ≥ 3 foods at the same time. Only 3 patients showed mono-sensitivity to birch pollen, while others were multi-sensitized to trees, grasses, weed, or house dust mite allergens.
Conclusion: OAS was the most common food allergy in birch pollen-sensitized patients. This study revealed the unique triggers of OAS in Korea in addition to well-known triggers.

Keywords: Birch Pollen; *Bet v 1*; Oral Allergy Syndrome; Pollen Food Syndrome

INTRODUCTION

Oral allergy syndrome (OAS), also known as pollen-food syndrome, is a type of contact allergic reaction that mainly occurs on oral contact with raw fruit, vegetables, or nuts.[1] The symptoms are manifested in the oropharynx, at the site of food contact, and include itching of the lips, tongue, and throat, and is sometimes accompanied by swelling of the lips and tongue.[2,3] It is caused when an inflammatory reaction is triggered due to cross-reactivity between birch pollen allergens and food proteins, leading to an allergic reaction.

Author Contributions

Conceptualization: Chang YS, Kim JH, Kim SH. Data curation: Chang YS, Kim JH. Formal analysis: Chang YS, Kim JH, Kim SH, Park HW, Cho SH. Writing - original draft: Chang YS, Kim JH, Kim SH, Park HW, Cho SH. Writing - review & editing: Chang YS, Kim JH.

The most common type of pollen-fruit cross-reaction is the birch pollen-related food allergy. The major birch pollen allergen, *Bet v 1*, belongs to the pathogenesis-related (PR) 10 protein family, and is recognized by immunoglobulin E (IgE) antibodies in > 90.0% of birch pollen-allergic patients.[4] Other members of the *Bet v 1*-related food proteins are apple (*Mal d 1*), peach (*Pru p 1*), apricot (*Pru ar 1*), cherry (*Pru av 1*), strawberry (*Fra a 1*), and pear (*Pyr c 1*), as well as hazelnut (*Cor a 1*), celery (*Api g 1*), carrot (*Dau c 1*), soybean (*Gly m 4*), celery (*Api g 1*), peanut (*Ara h 8*), and kiwi (*Act d 8*). These molecules cross-react with *Bet v 1* due to the high degree similarity between their amino acid sequences and the major birch pollen allergen, and thus, resulting in highly similar tertiary structure.[3,5,6]

Several studies have shown that ≥ 50.0% patients with birch pollen allergy develop OAS.[7-9] It is also reported that 75.0% of birch pollinosis patients develop OAS caused by apples.[10]

Although there is an increasing prevalence of birch pollinosis and birch pollen-related food allergy in clinical practice, no recent data on the prevalence and main triggers of this type of food allergy are available.[9,11,12] In addition, epidemiological surveys of OAS to date have been conducted mostly in western countries, such as Northern and Central Europe and North America, and few epidemiological studies have been conducted in Asian countries alone.[13,14] In Korea, epidemiological studies on OAS have not been conducted for the past 10 years.[13] In this study, we investigated the characteristics of OAS in birch pollen-sensitized patients.

METHODS

Study subjects and baseline data

To evaluate the prevalence and triggers of birch pollen-related food allergy, a retrospective chart review was conducted on 1,427 patients who underwent a skin prick test (SPT) for inhalant allergens at the Asthma and Allergy Clinic in Seoul National University Bundang Hospital, from January 2011 to December 2016.

Among 1,427 patients, those who presented a wheal > 3 mm and had an allergen-to-histamine wheal size ratio of at least 1 for birch pollen were selected using an electronic medical record system (BESTCare system®)[15-17] and analyzed. We evaluated the prevalence of OAS among birch pollen sensitized patients, compared the clinical features of patients with or without OAS, and evaluated the triggering foods of OAS.

SPTs

A SPT was conducted on the upper back using standardized techniques as previously described.[18-20] Positive control tests were performed using histamine (10.0 mg/mL). A positive skin response was defined as a wheal > 3.0 mm and an allergen-to-histamine wheal size ratio of at least 1. All subjects underwent skin prick testing for the following allergens: *Dermatophagoides pteronyssinus (Dp)*, *D. farina (Df)*, *Tyrophagus putrescentiae (Tp)*, cat epithelia, dog epithelia, *Blattella germanica*, *Aspergillus fumigatus*, *Alternaria tenuis*, tree pollens (alder, hazel, popular, elm, willow, birch, beech, oak, plane tree, Japanese cedar, elder, pine, acacia, and ash), grass pollens (velvet grass, orchard grass, rye grass, timothy grass, Kentucky blue grass, meadow grass, nettle, and Bermuda grass), weeds (mugwort, Japanese hop, dandelion, golden rod, plantain and ragweed), and latex (Allergopharma, Reinbek, Germany).

https://doi.org/10.3346/jkms.2018.33.e218

OAS

During the study period, all patients who demonstrated a positive response to birch pollen allergen on the SPT were asked whether they experienced oropharyngeal symptoms such as itchiness or swelling of the mouth, face, lip, tongue, and throat during certain food ingestion by an allergist. The allergist inquired about their symptoms and trigger foods, and the patients were clinically diagnosed with OAS.

Statistical analysis

Differences between the means were assessed using the two-sided t-test and proportions were compared using the two-sided χ^2 test. A P value of < 0.05 was considered to be statistically significant. All analyses were performed using the SPSS version 18.0 (SPSS Inc., Chicago, IL, USA).

Ethics statement

The protocol was approved by the Institutional Review Board (IRB) of Seoul National University Bundang Hospital (IRB No. B1703/388-111). Informed consent was waived by the board.

RESULTS

Among 1,427 patients who underwent a SPT, 125 (8.7%) were positive to birch pollen and **Table 1** shows the baseline characteristics of birch pollen sensitized patients.

In total, 20.8% (n = 26) of the study population experienced food allergy. OAS was the most frequent clinical manifestation (n = 25, 96.2%), and one patient presented with anaphylaxis to persimmon and ginseng. The incidence of OAS was 17.4% (n = 12) in males and 23.2% (n = 13) in females (P = 0.418). There was no significant difference between the birch pollen-sensitized patients with and without OAS in age (9.52 ± 13.83 years vs. 41.57 ± 15.58 years, P = 0.554) or serum eosinophil counts (206.99 ± 127.35 counts/μL vs. 247.37 ± 208.98 counts/μL, P = 0.412). The patients with OAS demonstrated a higher prevalence of asthma (20.0% vs. 45.0%, P = 0.024) and low serum total IgE levels, although these levels were not statistically significant (180.07 ± 164.99 U/mL vs. 380.98 ± 467.03 U/mL, P = 0.062). The percentage of patients with OAS who had rhinoconjunctivitis was 70% (n = 18), 20.0% (n = 5) patients had asthma, and 12.0% (n = 3) patients had chronic urticaria as comorbid diseases (**Table 2**).

Table 1. Baseline characteristics of birch pollen sensitized patients (n = 125)

Characteristics	Birch pollen sensitized patients
Age, yr	41.16 ± 15.398
Gender (% of male)	44.8 (n = 56)
Serum total IgE, IU/mL	341.19 ± 431.44
Blood eosinophil counts, No./μL	239.30 ± 195.51
Birch pollen mono-sensitive, %	2.4 (n = 3)
Comorbidities, %	
Asthma	40.0 (n = 50)
Rhinoconjunctivitis	76.0 (n = 95)
Chronic urticaria	8.0 (n = 10)
Atopic dermatitis	3.2 (n = 4)
Anaphylaxis	4.0 (n = 5)
Others[a]	5.6 (n = 7)

Data presented as means ± SD (range) or number (%).
SD = standard deviation, IgE = immunoglobulin E.
[a]Others include chronic cough, drug hypersensitivity, and dermatographism.

https://doi.org/10.3346/jkms.2018.33.e218

Table 2. Characteristics of the study participants according to OAS

Characteristics	OAS (+, n = 25)	OAS (−, n = 100)	*P* value
Age, yr	39.52 ± 14.83	41.57 ± 15.58	0.554
Gender (% of male)	52 (n = 13)	43 (n = 43)	0.502
Serum total IgE, IU/mL	180.07 ± 164.99	380.98 ± 467.03	0.062
Blood eosinophil counts, No./μL	206.99 ± 127.35	247.37 ± 208.98	0.412
Comorbidities, %			
Asthma	20 (n = 5)	45 (n = 45)	0.024
Rhinoconjunctivitis	72 (n = 18)	77 (n = 77)	0.607
Chronic urticaria	12 (n = 3)	7 (n = 7)	0.417
Atopic dermatitis	4 (n = 1)	3 (n = 3)	1.000
Anaphylaxis	12 (n = 3)	2 (n = 2)	-
Others[a]	0 (n = 0)	7 (n = 7)	-

Data presented as means ± SD (range) or number (%).
OAS = oral allergy syndrome, IgE = immunoglobulin E, SD = standard deviation.
[a]Others include chronic cough, drug hypersensitivity, and dermographism.

There was no difference in the prevalence of OAS between birch pollen-sensitized patients with allergic rhinoconjunctivitis (n = 95, 19.0%) and birch pollen sensitized patients without rhinoconjunctivitis (n = 30, 23.3%) (P = 0.601). The prevalence of OAS was significantly lower in birch pollen-sensitized asthma patients (n = 50) than that in asthma-free patients (n = 75) (10.0% vs. 26.67%, P = 0.022).

Apple (68.0%), peach (56.0%), nuts (36.0%), kiwi (20.0%), persimmon (20.0%), plum (16.0%), and cherry (16.0%) were frequent triggers; however, Chinese yam, kudzu vine, bellflower root, codonopsis, and ginseng were also reported to be triggers (**Table 3**). In addition, 60.0% of patients demonstrated OAS with ≥ 3 foods at the same time.

Of the 125 birch pollen-sensitive patients, only 3 were mono-sensitive to birch pollen, while the other patients exhibited multi-sensitivity to trees, grasses, weeds, or house dust mite allergens. In addition, birch pollen multi-sensitive patients were frequently sensitized to beech (71.2%), alder (68.0%) in tree pollens, velvet (22.4%) in grass pollens, and mugwort (32.8%) and Japanese hop (32.8%) in weed pollens. Patients sensitized to house dust mite allergens accounted for 58.4% (n = 73). Patients with OAS were more sensitized to willow trees (32.0% vs. 13.0%, P = 0.023) and less sensitized to *Dp* (32.0% vs. 60.0%, P = 0.012) than patients without OAS. **Fig. 1** shows allergen sensitization profiles compared by presence of OAS.

DISCUSSION

In this study, we investigated the unique triggers of OAS in Korea, such as persimmon, Chinese yam, kudzu vine, bellflower root, and ginseng, as well as well-known triggers, such as apple. Approximately 34.6% of pollen-sensitized patients and 48.0% of birch-sensitized patients are reported to exhibit symptoms of OAS.[13] In this study, the prevalence of OAS in birch pollen-sensitized patients (20.0%) was lower than that observed in the Western study population (50.0%–75.0%)[7-10]; however, it remains sufficiently high to warrant the clinician's attention.

In a previous Korean study, all patients sensitized to birch antigens were simultaneously sensitized to 5–6 types of tree pollen. In this study, the features of pollen sensitization were similar to those reported in previous studies, and only 3 patients were mono-sensitized to birch pollen alone.[13]

https://doi.org/10.3346/jkms.2018.33.e218

Table 3. Trigger foods of OAS in the study subjects

Food	No. (%)
Apple	17 (68.0)
Peach	14 (56.0)
Nuts	9 (36.0)
Almond	3
Peanut	4
Chestnut	2
Persimmon	5 (20.0)
Kiwi	5 (20.0)
Plum	4 (16.0)
Cherry	4 (16.0)
Watermelon	3 (12.0)
Apricot	3 (12.0)
Celery	2 (8.0)
Blueberry	2 (8.0)
Kudzu vine	2 (8.0)
Chinese yam	2 (8.0)
Melon	2 (8.0)
Ginseng	1 (4.0)
Sweet potato	1 (4.0)
Bellflower root	1 (4.0)
Mango	1 (4.0)
Strawberry	1 (4.0)
Pomegranate	1 (4.0)
Orange	1 (4.0)
Tangerine	1 (4.0)
Banana	1 (4.0)
Pear	1 (4.0)
Honey	1 (4.0)
Codonopsis	1 (4.0)
NT 3 or more	15 (60.0)
NT 2 or less	10 (40.0)

NT = numbers of trigger foods.

Interestingly, in addition to the foods commonly reported as triggers of OAS, such as apple and peach in western countries and previous studies, persimmon, Chinese yam, kudzu vine, bellflower root, codonopsis, and ginseng were revealed as trigger foods in this study. In persimmon, the *Dio k 4* allergen is known as the homolog of *Bet v 1*, and cross-reactivity with pollen allergens as a result of the presence of a profilin and *Bet v 6*- and *Bet v 1*-like allergens has been reported.[21] On the other hand, the bellflower root may cross-react with mugwort and birch pollen.[22,23] Studies have shown that immunoblotting with Chinese bellflower, birch, and mugwort revealed a common 40–55-kDa protein band that was very similar to the high-molecular-weight allergen responsible for the celery–birch–mugwort-spice syndrome.[22,23] Another possible protein that could cross-react with birch is an allergen of 14 kDa[22]; however, further studies are needed to investigate this. In a study involving 80 Korean birch-positive patients, 45% reported OAS to ginseng, but the exact allergen that caused the cross-reactivity was not determined.[24] There have been no reports on hypersensitivity reactions or studies of kudzu vine allergens. Kudzu vine belongs to the pea family, Fabaceae. *Bet v 5* and isoflavone reductase homolog proteins are present in pea, which are known as birch pollen minor allergens.[25] These could be involved in the cross-reactivity of kudzu vine and birch pollen. In addition, pomegranate has been reported to contain PR-4 protein, PR-14 protein (pomegranate allergy and PR protein 4 and 14), and *Pru p 3* allergen that cross-reacts with peach; it has a 29-kDa protein and 9–12-kDa protein as an allergen. However, the cross-reactivity of these proteins with the birch allergen has not yet been proved.[26] Chinese yam is rarely used as food in western countries, but it is often used in Asian countries, such as Korea, China, and Japan. Chinese yam-induced anaphylaxis has also been reported.[27]

https://doi.org/10.3346/jkms.2018.33.e218

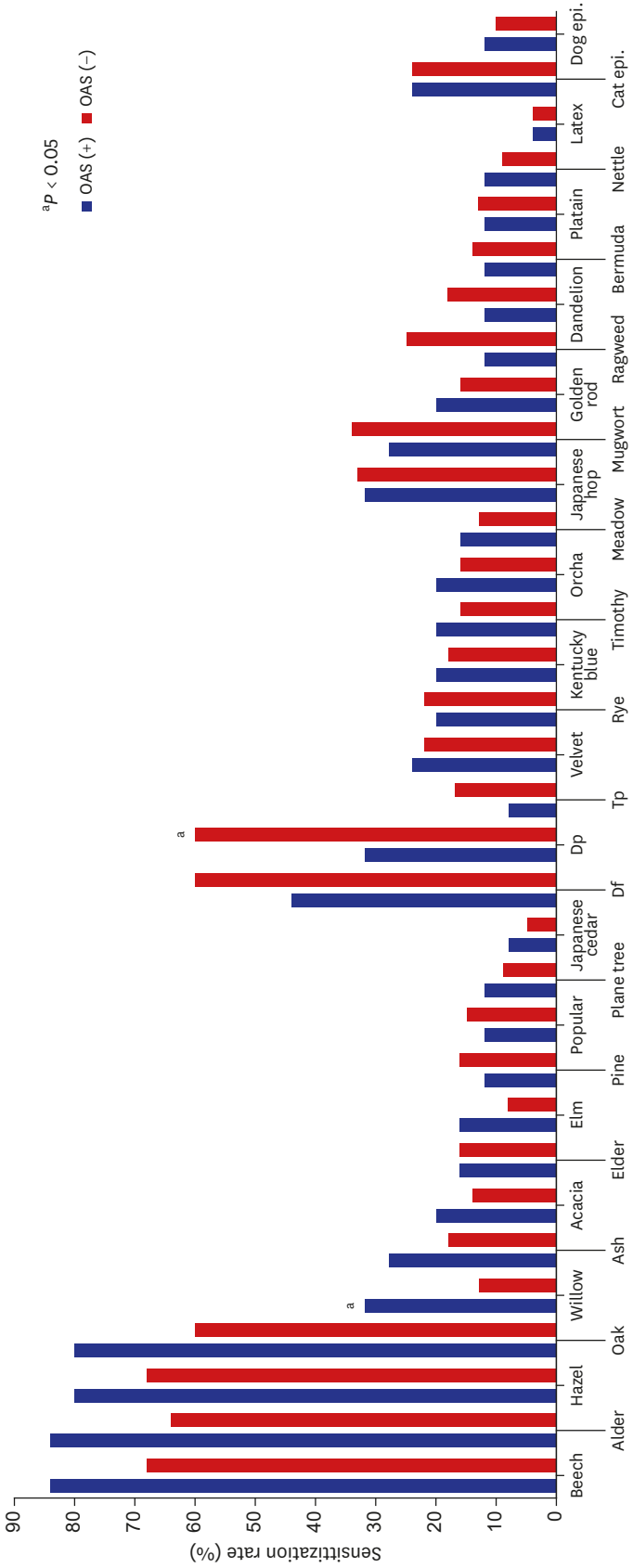

Fig. 1. Allergen sensitization profiles compared by presence of OAS. Patients with OAS were more sensitized to willow trees and less sensitized to *Dp* than patients without OAS.
OAS = oral allergy syndrome, Dp = *Dermatophagoides pteronyssinus*, Df = *Dermatophagoides farina*, Tp = *Tyrophagus putrescentiae*, epi. = epithelium.

https://doi.org/10.3346/jkms.2018.33.e218

Symptoms of OAS caused by fruits and vegetables are mild. However, laryngeal edema, and rarely, systemic anaphylaxis are reported to occur.[28,29] In this study, 1 patient presented anaphylaxis to persimmon and ginseng. In addition, rhinoconjunctivitis, asthma, generalized urticaria, conjunctivitis, and angioedema have been reported to concurrently occur with OAS, in addition to mild food-pollen syndrome.[29]

Although OAS can be prevented by avoiding consumption of the triggers, immunotherapy for pollinosis could be helpful. However, more prospective studies investigating this treatment are needed.[2,30-32]

This study has some limitations. This study was a retrospective chart review conducted at a university hospital. This could explain the low prevalence of OAS. Because this is a small one-center study, our result can not represent OAS in Korea. However, this study provided an insight into the characteristics of OAS in birch pollen-sensitized patients, and revealed other unique triggers of OAS in Korea, in addition to the well-known triggers.

Second, we only used SPT to confirm birch pollen sensitization, because SPTs are more sensitive than allergen-specific IgE test. However, more information about birch pollen specific IgE like *Bet v1*, *Bet v2*, and *Bet v6* may show some correlation with certain trigger food and it will help to find out allergen component of those food. Further research is needed in this area.

In conclusion, it was found that birch pollen sensitization rate was 8.7% by SPT with inhalant allergens. And the prevalence of OAS among birch pollen-sensitive patients was 20%. In addition to the well-known OAS triggers, Chinese yam, kudzu vine, bellflower root, and ginseng are also reported as triggers of OAS in Korean.

REFERENCES

1. Skypala IJ, Calderon MA, Leeds AR, Emery P, Till SJ, Durham SR. Development and validation of a structured questionnaire for the diagnosis of oral allergy syndrome in subjects with seasonal allergic rhinitis during the UK birch pollen season. *Clin Exp Allergy* 2011;41(7):1001-11.
PUBMED | CROSSREF
2. Mari A, Ballmer-Weber BK, Vieths S. The oral allergy syndrome: improved diagnostic and treatment methods. *Curr Opin Allergy Clin Immunol* 2005;5(3):267-73.
PUBMED | CROSSREF
3. Bohle B. The impact of pollen-related food allergens on pollen allergy. *Allergy* 2007;62(1):3-10.
PUBMED | CROSSREF
4. Geroldinger-Simic M, Zelniker T, Aberer W, Ebner C, Egger C, Greiderer A, et al. Birch pollen-related food allergy: clinical aspects and the role of allergen-specific IgE and IgG4 antibodies. *J Allergy Clin Immunol* 2011;127(3):616-622.e1.
PUBMED | CROSSREF
5. Bohle B. T-cell epitopes of food allergens. *Clin Rev Allergy Immunol* 2006;30(2):97-108.
PUBMED | CROSSREF
6. Oberhuber C, Bulley SM, Ballmer-Weber BK, Bublin M, Gaier S, DeWitt AM, et al. Characterization of Bet v 1-related allergens from kiwifruit relevant for patients with combined kiwifruit and birch pollen allergy. *Mol Nutr Food Res* 2008;52 Suppl 2:S230-40.
PUBMED
7. Vieths S, Scheurer S, Ballmer-Weber B. Current understanding of cross-reactivity of food allergens and pollen. *Ann N Y Acad Sci* 2002;964(1):47-68.
PUBMED | CROSSREF

8. Bircher AJ, Van Melle G, Haller E, Curty B, Frei PC. IgE to food allergens are highly prevalent in patients allergic to pollens, with and without symptoms of food allergy. *Clin Exp Allergy* 1994;24(4):367-74.
PUBMED | CROSSREF
9. Asero R, Massironi F, Velati C. Detection of prognostic factors for oral allergy syndrome in patients with birch pollen hypersensitivity. *J Allergy Clin Immunol* 1996;97(2):611-6.
PUBMED | CROSSREF
10. Ebner C, Birkner T, Valenta R, Rumpold H, Breitenbach M, Scheiner O, et al. Common epitopes of birch pollen and apples--studies by western and northern blot. *J Allergy Clin Immunol* 1991;88(4):588-94.
PUBMED | CROSSREF
11. Eriksson NE, Formgren H, Svenonius E. Food hypersensitivity in patients with pollen allergy. *Allergy* 1982;37(6):437-43.
PUBMED | CROSSREF
12. Stevens WJ, Ebo DG, Hagendorens MM, Bridts CH, De Clerck LS. Is the prevalence of specific IgE to classical inhalant aeroallergens among patients with respiratory allergy changing? Evidence from two surveys 15 years apart. *Acta Clin Belg* 2003;58(3):178-82.
PUBMED | CROSSREF
13. Cho YS, Lim YJ, Lee JC, Kim SH, Lim MK, Yoo B, et al. Oral allergy syndrome in pollen-sensitized patients. *J Asthma Allergy Clin Immunol* 1998;18(3):458-65.
14. Lin RY, Clauss AE, Bennett ES. Hypersensitivity to common tree pollens in New York City patients. *Allergy Asthma Proc* 2002;23(4):253-8.
PUBMED
15. Yang MS, Choi SI, Song WJ, Kim SH, Kang HR, Park HW, et al. Impact of an electronic consultant system on hypersensitivity reactions to iodinated radiocontrast media: an observational study. *Postgrad Med J* 2015;91(1074):193-9.
PUBMED | CROSSREF
16. Yoo S, Lee KH, Lee HJ, Ha K, Lim C, Chin HJ, et al. Seoul National University Bundang Hospital's electronic system for total care. *Healthc Inform Res* 2012;18(2):145-52.
PUBMED | CROSSREF
17. Kim MH, Park CH, Kim DI, Kim KM, Kim HK, Lim KH, et al. Surveillance of contrast-media-induced hypersensitivity reactions using signals from an electronic medical recording system. *Ann Allergy Asthma Immunol* 2012;108(3):167-71.
PUBMED | CROSSREF
18. Bernstein IL, Li JT, Bernstein DI, Hamilton R, Spector SL, Tan R, et al. Allergy diagnostic testing: an updated practice parameter. *Ann Allergy Asthma Immunol* 2008;100(3 Suppl 3):S1-148.
PUBMED | CROSSREF
19. Bernstein IL, Storms WW. Practice parameters for allergy diagnostic testing. Joint Task Force on Practice Parameters for the Diagnosis and Treatment of Asthma. The American Academy of Allergy, Asthma and Immunology and the American College of Allergy, Asthma and Immunology. *Ann Allergy Asthma Immunol* 1995;75(6 Pt 2):543-625.
PUBMED
20. Rusznak C, Davies RJ. ABC of allergies. Diagnosing allergy. *BMJ* 1998;316(7132):686-9.
PUBMED | CROSSREF
21. Bolhaar ST, van Ree R, Ma Y, Bruijnzeel-Koomen CA, Vieths S, Hoffmann-Sommergruber K, et al. Severe allergy to sharon fruit caused by birch pollen. *Int Arch Allergy Immunol* 2005;136(1):45-52.
PUBMED | CROSSREF
22. Kim SH, Lee SM, Park HW, Cho SH, Min KU, Kim YY, et al. Chinese bellflower root anaphylaxis: IgE-binding components and cross-reactivity with mugwort and birch. *Korean J Intern Med* 2009;24(3):279-82.
PUBMED | CROSSREF
23. Egger M, Mutschlechner S, Wopfner N, Gadermaier G, Briza P, Ferreira F. Pollen-food syndromes associated with weed pollinosis: an update from the molecular point of view. *Allergy* 2006;61(4):461-76.
PUBMED | CROSSREF
24. Kim M, Choi E, Yoon T. Korean ginseng makes oral allergy syndrome in birch-sensitized respiratory allergy patients. *J Allergy Clin Immunol* 2008;121(2):S187.
CROSSREF
25. Karamloo F, Schmitz N, Scheurer S, Foetisch K, Hoffmann A, Haustein D, et al. Molecular cloning and characterization of a birch pollen minor allergen, Bet v 5, belonging to a family of isoflavone reductase-related proteins. *J Allergy Clin Immunol* 1999;104(5):991-9.
PUBMED | CROSSREF

26. Almeida EM, Bartolomé B, Faria EG, Sousa NG, Luís AS. Pomegranate anaphylaxis due to cross-reactivity with Peach LTP (Pru p 3). *Allergol Immunopathol (Madr)* 2015;43(1):104-6.
PUBMED | CROSSREF

27. Lee SY, Ahn K, Kim J, Jang GC, Min TK, Yang HJ, et al. A Multicenter retrospective case study of anaphylaxis triggers by age in Korean children. *Allergy Asthma Immunol Res* 2016;8(6):535-40.
PUBMED | CROSSREF

28. Ortolani C, Ispano M, Pastorello E, Bigi A, Ansaloni R. The oral allergy syndrome. *Ann Allergy* 1988;61(6 Pt 2):47-52.
PUBMED

29. Ortolani C, Pastorello EA, Farioli L, Ispano M, Pravettoni V, Berti C, et al. IgE-mediated allergy from vegetable allergens. *Ann Allergy* 1993;71(5):470-6.
PUBMED

30. Kelso JM, Jones RT, Tellez R, Yunginger JW. Oral allergy syndrome successfully treated with pollen immunotherapy. *Ann Allergy Asthma Immunol* 1995;74(5):391-6.
PUBMED

31. Mauro M, Russello M, Incorvaia C, Gazzola G, Frati F, Moingeon P, et al. Birch-apple syndrome treated with birch pollen immunotherapy. *Int Arch Allergy Immunol* 2011;156(4):416-22.
PUBMED | CROSSREF

32. Bucher X, Pichler WJ, Dahinden CA, Helbling A. Effect of tree pollen specific, subcutaneous immunotherapy on the oral allergy syndrome to apple and hazelnut. *Allergy* 2004;59(12):1272-6.
PUBMED | CROSSREF