

Pediculus humanus capitis: an update

I. Nutanson, C.J. Steen, R.A. Schwartz, and C.K. Janniger

S U M M A R Y

Head lice infestation, or pediculosis capitis, caused by *Pediculus humanus capitis*, is a common health concern. In the US, where pediculosis capitis is the most prevalent parasitic infestation of children, 6 to 12 million people are affected every year. Pediculosis capitis remains confined to the scalp. Scalp pruritus is the cardinal symptom, although patients with lice can be asymptomatic. Pruritus with impetiginization should prompt the physician to look for lice or viable nits. All close contacts should be examined. Treatment directed at killing the lice and the ova should be considered only if active lice or viable eggs are observed. The three fundamental effective treatment options for head lice are topical pediculicides, wet combing, and oral therapy. Spraying or fogging a home with insecticides or pediculicides is not recommended.

K E Y W O R D S

**pediculosis
capitis,
pruritus,
lice,
infestations,
arthropods**

Introduction

Pediculosis capitis, also known as head lice infestation, caused by *Pediculus humanus capitis*, is a frequent community health concern. Infestation occurs most commonly in children, with a peak incidence between 5 and 13 years of age (1, 2). Although *P. humanus capitis* is not a vector of human disease and poses no significant health risk to infested persons (3, 4), head lice infestation can cause substantial social distress, discomfort, parental anxiety, embarrassment to the child, and unnecessary absence from school and work (2).

Characteristics of lice

The head louse, *Pediculus humanus capitis*, is a host-specific arthropod that is 1 to 3 mm long and is grayish-whitish in color. It has narrow sucking mouthparts concealed within the head, short antennae, and three pairs of clawed legs adapted for grasping hair (5, 6) (Figure 1). A louse feeds by sucking blood and simultaneously injecting saliva with vasodilatory and anticoagulation properties into the host. Head lice move at a speed of up to 23 cm/min (7) and are incapable of jumping or flying.

Lice egg sheaths, referred to as nits, are firmly glued to individual hairs (5) (Figure 2). Eggs are 0.8 mm in length and are laid within 1 to 2 mm of the scalp surface. Rarely, nits can be seen along the length of the hair shaft (5).

One female can lay about 150 eggs during a 30-day life span. Young lice hatch within 1 week and go through 3 nymphal instar stages, growing larger and maturing to adults over a period of 7 days (5) (Figure 3). The first and second instar forms are relatively immobile and therefore are not easily transmitted between individuals; most spread is related to the third instar forms and adults (10). Head lice can survive for up to 3 days off the host; nits can endure 10 days of separation from the host (12).

Epidemiologic characteristics

In the US, pediculosis capitis affects about 6 to 12 million people every year (4, 5). The prevalence of head lice remains high; epidemics occur regularly despite all efforts at control in the UK (13). No age or economic stratum is immune to *P. humanus capitis*, although crowded living conditions tend to be associated with a higher prevalence of infestation (14). *P. humanus capitis* is the most common parasitic infection of children (14). Head lice infestation is not influenced by hair length or frequency of shampooing or brushing (15, 16). Girls are about twice as likely to get head lice as boys (17). Infestations in the US are less common in blacks, due to physical characteristics of their hair shaft, which is more oval-shaped and is therefore more difficult to grasp (14–16).

Head-to-head contact is the most important mode of transmission (19). Pediculosis capitis can be transmitted by infested clothing, hats, hairbrushes, combs, towels, bedding, and upholstery (20).

Clinical manifestations

Head lice infestations are characterized by nits attached to hairs approximately 0.7 cm from the scalp (20). Nits are often found in the occipital and retro-auricular portions of the head and are easier to observe than crawling adult lice. Pruritus is the principal symptom, although patients with lice can be asymptomatic (21). Bite reactions, excoriations, secondary impetiginization, pyoderma, cervical lymphadenopathy, conjunctivitis, fever, and malaise are also possible manifestations (1, 21, 22). Pyoderma may be accompanied by alopecia (1). A morbilliform hypersensitivity rash can mimic a viral exanthema. In longstanding cases, dermatitis of variable severity can be seen, characterized by exudation and crusting, especially in the occipital region.

Uncommonly, in heavily infested and untreated patients, the hair can become tangled with exudates, predisposing the area to fungal infection. This results in a malodorous mass. Countless lice and nits can be found under the entangled hair mass (23).

New bites may cause reactivation of already healed bites (22). The most likely cause of the bite reactions seems to be the inflammatory response to injected louse saliva or anticoagulant (24). At the time of the first lice infestation, pruritus may not be seen for 1 to 2 months because it takes time to develop sensitivity (15, 16). Therefore, by the time the patient is symptomatic, he or she may have been infested for at least 1 month already.

Histopathologic characteristics

The classic lesion shows a deep wedge-shaped intradermal hemorrhage with a perivascular infiltrate of lymphocytes, histiocytes, and eosinophils within the dermis (23, 25).

Diagnosis

The gold standard for diagnosing head lice is the identification of a live louse, nymph, or a viable nit on the head. Because head lice avoid light and crawl quickly, visual inspection without combing is difficult (5, 15, 16). Using lice combs increases the chances of finding live lice and is a helpful screening tool (26, 27). The diagnosis of lice infestation using a lice comb is fourfold more efficient than a direct visual examination.

The tiny nits are easier to observe, especially at the nape of the neck or behind the ears (15, 16). Nits by themselves are not diagnostic of active infestation. However, if the nits are found within 0.7 cm of the scalp, active infestation is likely (5). Recognition can be facilitated by a magnifying glass. Wood's lamp examination reveals yellow-green fluorescence of the lice and their nits (23). Dermoscopy is also a possible aid in the diagnosis and follow-up of pediculosis capitis. There are new generations of handheld dermoscopes that do not require direct contact, preventing the possible risk of transferal (28). Pruritus with impetiginization should alert the physician to look for lice or viable nits (1).

Dead eggs can remain glued to the hair shafts for as long as 6 months. Human hair grows at a rate of approximately 1cm/month. As the hair grows, the cemented empty nits move away from the scalp. After 2 to 3 months, these empty nits become more visible, especially on dark hair. This appearance of "nits" several months after a treatment can lead to a false-positive diagnosis of an active infestation because most people cannot differentiate between viable and empty

Table 1. Pediculosis capitis differential diagnosis.

No.	Diagnosis
1.	Inner root sheath remnants (hair casts)
2.	Black piedra
3.	White piedra
4.	Trichodystrophies (monilethrix and trichorrhexis nodosa)
5.	Psoriasis
6.	Hair spray debris
7.	Seborrheic dermatitis
8.	Psocids (book lice)

eggs, and assume that if eggs are present the child must also have lice (29). Therefore, the importance of identifying a live moving louse, nymph, or viable nit on the head for correct diagnosis cannot be stressed enough.

Differential diagnosis

Differential diagnosis includes inner root sheath remnants (hair casts), as well as black and white piedra, caused by *Piedraia hortae* and *Trichosporon beigelii* (30, 31). Trichodystrophies, such as monilethrix and trichorrhexis nodosa, and scalp conditions such as psoriasis and eczema have also been mistaken for nits on gross examination. Nits can also be confused with debris on the hair shaft left by hair spray, dandruff, or accumulated flakes of seborrheic dermatitis (5, 32). As opposed to nits, hair casts and flakes are freely movable along the hair shaft. The correct diagnosis can be established by microscopic examination. Table 1.

Psocids are lice-like insects (booklice) that can rarely cause human scalp infestation; they are readily differentiated from human lice by their larger heads, large mouthparts, large hind legs, and long antennae (5, 6, 33).

Treatment

Every member of the household and all other close contacts should be examined (1). Treatment should be considered only if live lice or viable nits are observed (34). All clothing, towels, bed linens, stuffed animals, and cloth toys used by an infested child within 2 days prior to diagnosis should be washed in water hotter than 50 °C, or machine dried at the highest heat setting, for at least 30 minutes. Headgear, combs, headphones, and helmets should be cleaned and disinfected with a pediculicide or isopropyl alcohol (15, 16, 35, 36). If none of the aforementioned modalities is plausible, sealing the

objects in a plastic bag for 2 weeks is also an option to ensure decontamination. Floors, rugs, play areas, pillows, carpet squares, and upholstered furniture should be vacuumed to eliminate any shed hairs with viable eggs (1, 2, 10, 15, 16, 35–37). The treatment should be directed at killing the lice and the ova. There are three effective basic treatment options for head lice: topical pediculicides, wet combing, and oral therapy (10, 15, 16, 35–37). Pediculicides are the most efficacious treatment for pediculosis capitis (15, 16, 38, 39). Agents with long residual effect are more likely to be ovicidal (15, 16). Treatment failures are often due to noncompliance, improper application of pediculicides, or reinfestation, and, rarely, resistance to pediculicides (2, 5, 15, 16). Pediculicides are not recommended for children younger than 2 years (39, 40).

Topical agents

Pyrethrin: The treatment of choice for head lice infestation in the US is a synthetic pyrethrin, 1% permethrin cream rinse. The hair is first shampooed with a non-conditioning shampoo and towel dried. Thereafter, a 1% permethrin cream rinse is applied, left on for 10 minutes and then rinsed off (5, 10, 15, 16, 20, 39, 41). Permethrin acts as a neurotoxin by disrupting the sodium channel current, causing delayed repolarization, and subsequent paralysis of the nerves in exoskeletal muscle that allows the lice to breathe (42). Permethrin is the only pediculicide with a residual activity lasting for over 2 weeks. It is both pediculicidal and ovicidal (5, 15, 16, 39, 41–43). Therefore, one treatment is generally adequate. However, a second course, 7 to 10 days later, ensures a 95% cure rate. Resistance to 1% permethrin has been reported, but the prevalence of this resistance is unknown (15, 16, 20, 36, 38, 41, 44–46).

Pyrethrins plus piperonyl butoxide are manufactured from natural chrysanthemum extracts and are neurotoxic to lice. Natural pyrethrins have low mammalian toxicity, but could cause a reaction in individuals that are allergic to chrysanthemums or ragweed (9, 12, 15, 16). These over-the-counter products are mostly shampoos that are applied to dry hair and left on for 10 minutes before rinsing out.

None of the natural pyrethrins are completely ovicidal because newly laid ova lack a nervous system for the first 4 days. About 20% to 30% of the eggs remain viable after the first treatment. This requires reapplication 7 to 10 days later to kill newly emerged nymphs hatched from eggs that survived (9, 12, 15, 16, 41). Resistance of adult lice to these products has been reported (9, 12, 15, 16, 49, 50).

Malathion (0.5%) is an organophosphate (acetylcholinesterase inhibitor) that works by causing respiratory paralysis in the arthropod (41, 42). It is available

only by prescription in the US, and is an over-the-counter agent in the UK. This agent is a lotion that has to be applied to the hair, left to air dry, and washed off after 8 to 12 hours. Malathion has high ovicidal activity, but the product should be reapplied if live lice are seen in 7 to 10 days. The major concerns are the high alcohol content of the product, making it highly flammable (hair dryers or curling irons should be avoided during treatment) (1), and the risk of severe respiratory depression in case of accidental ingestion. It should be used with extreme caution in cases in which resistance to other pediculicidal products is strongly suspected (15, 16, 37, 38, 51).

Permethrin (5%) is a cream, available only by prescription in the US. This product is usually applied overnight for scabies. It is not currently approved by the Food and Drug Administration for use as a pediculicide. It has anecdotally been recommended for the treatment of head lice that appear to be refractory to other treatments. It is applied to the scalp and left on for several hours or overnight, after which it should be rinsed off (52). No case-control studies have reported efficacy to date. One study suggested that lice resistant to 1% permethrin will not succumb to higher concentrations (46).

Crotamiton (10%) is a lotion, available only by prescription in the US. It is not currently approved by the FDA and is used to treat scabies. A single study showed it to be effective against head lice when applied to the scalp and left on for 24 hours before rinsing out (53). Safety and absorption in children, adults, and pregnant women were not evaluated.

Carbaryl (0.5%), available in the UK by prescription only, is a carbamate that binds to the same site on the acetylcholinesterase enzyme as organophosphates. In the UK in 1981, an open-label clinical study with 0.5% carbaryl lotion achieved a 100% cure rate in 81 participants. In 2000, an in-vitro survey showed prolonged survival of head lice with carbaryl exposure in one UK region. A follow-up, non-randomized, open-

label clinical trial showed an 89% cure rate in this region compared with a 100% cure rate in another region. Carbaryl use is falling out of favor, based in part on evidence that it might be carcinogenic. The Department of Health in the UK acknowledges that carbaryl has a mutagenic potential, and should continue to have restricted use only (42, 54, 55).

Lindane (1%) is an organochloride that has central nervous system toxicity in humans. Several cases of severe seizures in children using lindane were reported (56–61). The use of lindane for treatment of lice or scabies was banned by California in 2002 due to concern over water supply contamination. It is available by prescription only, as a shampoo that should be left on for no more than 10 minutes, with repeated application in 7 to 10 days. It has low ovicidal activity, and resistance has been reported worldwide for many years. It should be used very cautiously. Lindane is contraindicated for pregnant or nursing women, in patients with seizure disorders, and in patients with hypersensitivity to the product. The FDA has issued a public health advisory on the safety of lindane products (15, 16, 56–62).

All topical pediculicides have to be rinsed from the hair over a sink, rather than in the shower or bath to limit exposure; and with cool water, in order to minimize absorption due to vasodilatation (49).

Pediculicide resistance

None of the currently available topical pediculicides is 100% ovicidal, and resistance to all of them has been reported. A study conducted in the UK in 2000 concluded that there was high resistance to permethrin, phenothrin, and malathion, with an 87% failure rate for permethrin and a 64% failure rate for malathion with the topical treatment (63). There are no reports of widespread malathion resistance in the US. The prevalence of resistance is not known. When faced with a persis-

Table 2. Guidelines for schools regarding children with head lice.

No.	Guideline
1.	A child with active head lice infestation may be allowed to remain in class until the end of the school day, but be discouraged from close head contact with others.
2.	The child's parent or guardian should be notified the same day and provided with information regarding the diagnosis and treatment, and advised to screen all household members and close contacts for head lice.
3.	The child should be allowed to return to school immediately after the first treatment.
4.	"No nits" policies of return to school should be discouraged.
5.	Parents or guardians of all children in the classroom should be notified and advised to check their children for head lice.
6.	The school nurse should check the child with a lice comb 10 days after the letter was sent to the parents, and contact the parents if lice are detected.

Figure 1.
Head louse.
Courtesy of
the CDC.



tent case of head lice, several additional possible explanations must be considered, including: misdiagnosis, noncompliance, re-infestation, lack of ovicidal or residual pediculicidal properties of the product, incorrect application, or resistance of lice to the agent (15, 16, 42, 44–47, 49–52, 64).

Nit removal after treatment with a pediculicide

Because none of the pediculicides are 100% ovicidal, manual removal of nits with a fine-toothed nit comb after treatment with any product is recommended. Nit removal can be difficult and time consuming (65). Removal of nits with a lice comb is easier when the hair is wetted with water, or after shampooing or treatment with a conditioner (29).

Some products are available that claim to loosen the “glue” that attaches nits to the hair shaft, making the process easier. Vinegar or vinegar-based products (Clear Lice Egg Remover Gel) are intended to be applied to the hair for 3 minutes before combing out the nits. No clinical benefit has been demonstrated (52, 66).

8% formic acid applied to wet hair for 10 minutes before combing out the nits has been shown to have some benefit in one study (67). Acidic solutions (pH

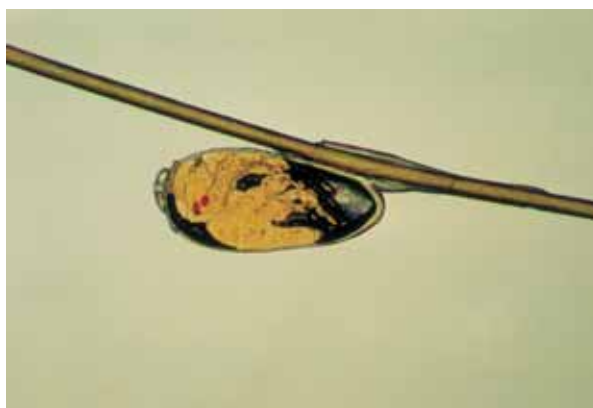


Figure 2. Head louse nit. Courtesy of the CDC.

4.5–5.5) probably make the surface of the hair smoother, facilitating sliding the eggs off the hair (29). Neither of these products is recommended for use with permethrin because they may interfere with that product’s residual activity (15, 16).

Wet combing

Mechanical removal of lice with the use of wet combing is an alternative to insecticides. The rationale behind it is the fact that lice cannot move to another host within 7 days after hatching, and cannot reproduce within 10 days, and all eggs hatch within 7 to 10 days. Therefore, if all young lice are combed out a few days after hatching, the infestation can be eradicated completely. The combing procedure is done on wet hair with added lubricant (hair conditioner or olive oil) and continued until no lice are found (15 to 30 minutes per session or longer for long, thick hair). Combing is repeated once every 2 to 3 days for several weeks and should continue for 2 weeks after any session in which an adult louse is found. This approach cured 38% of children in a trial conducted in 2000 in the UK, in which the treatment was carried out by parents, but it was only half as effective as malathion treatment (15, 16, 37, 68). However in 2005 a new trial was conducted in the UK comparing the effectiveness of a current Bug Buster® kit with over-the-counter pediculicides containing malathion or permethrin. The cure rate for wet combing with conditioner employing the Bug Buster® kit was found to be significantly greater than that for the over-the-counter pediculicides (57% *v* 13%) (69).

Oral agents

Sulfamethoxazole/Trimethoprim as used in otitis media doses was shown to be effective against head lice (15, 16). This antibiotic is thought to kill the



Figure 3. Head louse emerging from the nit. Courtesy of the CDC.

Table 3. Parental education for the management of head lice.

No.	Guideline
1.	Head lice are very common, are not known to transmit any disease, pose no serious health risk for the child, and are not indicative of poor hygiene.
2.	The major symptom of head lice infestation is pruritus; however, the child may have no symptoms.
3.	Diagnosis is best made with a fine-toothed lice detection comb, and should be based upon the presence of a live moving louse or a nymph.
4.	Once the diagnosis is made, the affected child should be treated with appropriate over-the-counter or prescription medication that kills the head lice and their eggs.
5.	Apply lice medicine, also known as pediculicide, paying careful attention to the label instructions. If the hair is longer than shoulder length, a second bottle of pediculicidal medication may be needed.
6.	Avoid using a cream rinse or combination of shampoo/conditioner before using lice medicine. Do not rewash hair for 1 to 2 days after treatment.
7.	The infested person should put on clean clothing immediately after treatment.
8.	Use a fine-toothed lice comb immediately after treatment and the following day to comb out any lice or nits.
9.	If, after 8 to 12 hours after treatment, a few live lice are found, but they seem to move more slowly than before, do not retreat. Comb dead and remaining live lice out of the hair. It may take longer for the medicine to kill lice.
10.	If, after 8 to 12 hours of treatment, the lice seem as active as before, see a healthcare provider.
11.	After treatment, comb with a nit comb to remove nits and lice every 2 to 3 days. Continue to check for 2 to 3 weeks until you are sure all lice and nits are gone.
12.	Wash used clothing and bedding in water hotter than 50 °C, or machine dry at the highest heat setting, for at least 30 minutes.
13.	Headgear, combs, headphones, and helmets should be cleaned and disinfected with a pediculicide or isopropyl alcohol, or sealed in a bag for 2 weeks.
14.	If using over-the-counter pediculicides, reapply in 7 to 10 days.
15.	If using the prescription drug malathion, reapply in 7 to 10 days only if crawling lice are found.
16.	All household members and close contacts of the patient should be screened for head lice and treated as necessary.

Based on the US Centers for Disease Control and Prevention guidelines (86).

symbiotic bacteria in gut flora of the louse, thereby interfering with its ability to synthesize vitamin B. Death ensues from vitamin B deficiency (1, 2, 70). In a recent study, this antibiotic demonstrated synergistic activity when used in combination with permethrin 1% when compared with permethrin 1% or sulfamethoxazole/trimethoprim used alone. However, the treatment groups were small (70). Severe life-threatening allergic reactions, including Stevens-Johnson Syndrome and toxic epidermal necrolysis, despite being rare, make it an undesirable therapy if other alternatives exist (15, 16, 56). It is not currently approved by the FDA for use as a pediculicide (15, 16). We do not recommend it.

Several anti-helminthic agents including ivermectin, levamisole, and albendazole may be effective treatments for pediculosis capitis (71). **Ivermectin is an** anti-helminthic agent structurally similar to the macrolide antibiotics, but without antibacterial activity (71–73). A single oral dose of 200 micrograms/kg, repeated

in 10 days, was shown to be effective against head lice. This agent is also suggested as a good option for treatment of mass infestations. If ivermectin crosses the blood-brain barrier, it blocks essential neural transmission. Young children are at a higher risk for this adverse drug reaction. Therefore ivermectin should not be used for children that weigh less than 15 kg and in children younger than 5 years. This product is not currently approved by the FDA as a pediculicide (5, 15, 16, 33, 72–75). **Levamisole** at a dose of 3.5 mg/kg once daily was suggested to be effective against pediculosis upon administration for 10 days (71). **Albendazole** in a single dose of 400 mg, or a 3-day course of albendazole 400 mg, is effective against pediculosis capitis, with a repeated single dose of albendazole 400 mg after 7 days. No synergistic effect between albendazole and 1% permethrin was found (71). The use of these systemic treatments for head lice is only justified in severe infestation when topical treatments have failed or are ineffective (15, 16, 37, 41, 42, 72, 73).

Occlusive agents

The use of a "petrolatum shampoo," consisting of standard petroleum jelly massaged on the entire surface of the scalp and hair and left on overnight with a shower cap, was suggested to be effective (15, 16). Thorough shampooing is required for the next 7 to 10 days to remove the entire residue. This thick substance obstructs the respiratory spiracles of the louse, preventing efficient air exchange, as well as the holes in the operculum of the eggs, resulting in death by suffocation (76). Another interpretation is that the intense attention to hair grooming results in removal of all the lice and nits.

Hair pomades are easier to remove than petroleum jelly, but may not kill the eggs, and treatment should be repeated weekly for 4 weeks (15, 16, 18, 66). Other occlusive substances have been suggested (mayonnaise, tub margarine, herbal oils, olive oil), but to date only anecdotal information is available regarding their efficacy (15, 16).

During the past year, two new products for treating head lice were released in the UK: 4% dimethicone (Hedrin®) lotion and Full Marks® solution. These products act by coating the louse and disrupting its ability to manage water. Hedrin® was found to cure at least 70% of cases in two clinical trials (77). There is no clinical evidence to support Full Marks® product effectiveness yet (39).

A recent study (78, 79) suggests that Cetaphil® cleanser can be used as a dry-on, suffocation-based pediculicide lotion (**NUVO® lotion**), and is effective in the treatment of pediculosis capitis (78, 79). However the study was anecdotal, not a well-designed randomized trial, and did not use a proper method to make the diagnosis of head lice infestation (80, 81).

Head lice repellents

The insecticide residues left on hair shafts probably act as insect repellents even if the louse is resistant to the lethal effects of the insecticide. Piperonal is available as a head lice repellent spray. Lavender, citronella, and anise are also shown to be effective lice repellents

in in-vitro studies (54). Citronella repellent formulation was found to be 3 to 4 times more effective than the placebo in protecting against head lice infestation (82).

Summary

Head lice infestation is associated with little morbidity, but causes much anxiety, days lost from school and work, and millions of dollars spent on medications. Pediculosis capitis remains a prevalent disease that necessitates a multidisciplinary treatment approach. Adults should be aware of the signs and symptoms of head lice infestation; affected children should be treated promptly to minimize spread to others. The school or child care facility should be notified immediately so that additional cases can be detected and treated in a timely manner. Chemical pediculicides should be used rationally and in conjunction with nonchemical treatment modalities to prevent emergence of resistance (2). Therapy rotation may also slow the appearance of resistant species (83). Healthy children should not be excluded from school due to head lice. The "no nit" policies for return to school needlessly keep many children out of school, and create significant financial difficulties for their parents (Table 2). These policies should be discouraged because they usually result in many children with nonviable nits being kept out of school while asymptomatic children with active infestation remain in the classrooms (5, 29, 37, 38, 42). Because most children with nits alone will not become infested, excluding these children from school and requiring them to be treated with a pediculicide is unwarranted. Due to the fact that most available pediculicides are incomplete ovicides, treating children with nits alone may not prevent subsequent infestation. Instead, children with nits alone should have regular follow-up examinations with a lice comb during the following 14 days. Children with more than 5 nits within 0.7 cm of the scalp are at higher risk of becoming infested and may need more frequent follow-up examinations (84). Parental education programs are helpful in managing head lice (Table 3). Only through improved understanding of the biology and physiology of the head louse can we effectively employ new and existing treatment modalities (85).

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A U T H O R S ' A D D R E S S E S *Inna Nutanson MD, Dermatology, New Jersey Medical School, 185 South Orange Avenue, Newark, New Jersey 07103-2714*
Christopher J. Steen MD, Dermatology, same address
Robert A. Schwartz MD, MPH: Professor & Head, Dermatology, New Jersey Medical School, same address
CK Janniger MD: Professor & Chief, Pediatric Dermatology, New Jersey Medical School, same address