ARTICLE

A Clinical Diagnostic and Treatment Protocol for the Patient with Visual Snow/Visual Snow Syndrome and Concurrent Binocular Dysfunctions

Daniella Rutner, OD, MS, MBA, FCOVD1
Kenneth J. Ciuffreda, OD, PhD, FCOVD-A1
1SUNY College of Optometry, Vision Rehabilitation Service, SUNY Visual Snow Group

ABSTRACT

Purpose
The objective of the present paper is to propose the first comprehensive, clinical protocol for patients having visual snow (VS)/visual snow syndrome (VSS) with respect to diagnostic and therapeutic aspects, including their concurrent non-strabismic, binocular vision/oculomotor dysfunctions which are in high prevalence.

Method
Based on our experience over the past five years and that of our colleagues, as well as an extensive literature search (i.e., Pubmed, Google, Google Scholar, APA PsychNet, Semantic Scholar, and related papers/books), a comprehensive clinical, neuro-optometric protocol was developed for this population. It emphasizes the diagnosis and remediation of visual snow via detailed case history, specific questionnaires, and chromatic tints along with environmental alterations, as well as the related and common concurrent binocular vision/oculomotor dysfunctions using conventional oculomotor-based vision therapy, at times in combination with the precision chromatic tint.

Results
A comprehensive clinical protocol for the patient with visual snow/visual snow syndrome and their frequent concurrent, non-strabismic, binocular vision problems (e.g., convergence insufficiency) was developed. The treatment strategies involved the use of chromatic filters and oculomotor-based vision therapy, respectively, both independently and combined.

Conclusion
For the first time, a comprehensive clinical protocol for patients with visual snow syndrome and their prevalent binocular vision problems has been conceptualized and formulated. It should result in improved patient care in this population. Over the years, it is likely to be revised as additional clinical experiences and scientific advances take place.

INTRODUCTION

Individuals having sustained a concussion/mild traumatic brain injury (C/mTBI) may report a constellation of general dysfunctions. They include those of a sensory, motor, perceptual, cognitive, linguistic, behavioral, and emotional nature.1,2 Thus, their treatment is frequently interdisciplinary, and hence it is typically spearheaded by a physiatrist, neurologist, and/or case manager.

More specifically, the visual system is frequently adversely affected. This is not unexpected. Fifty percent of the cortex is involved in visual processing, including 300 intracortical tracts linking over 30 cortical areas.3 Some of the related visual...
symptoms include diplopia, blur, visual motion sensitivity, oculomotor-based reading difficulties, photosensitivity,\textsuperscript{1,2} and more recently “visual snow (VS)”\textsuperscript{4-11}.

Visual snow (VS) refers to the cortically-based, visual perception of a pixelated overlay of “dots” (i.e., dynamic visual noise) in the foreground of one’s visual field (Figure 1)\textsuperscript{4-11}. VS can be either chromatic or monochromatic, and either transient or constant, in nature. The primary symptom is the perception of VS and is part of a broader diagnosis of “visual snow syndrome (VSS)”\textsuperscript{4-11}. This syndrome includes an array of additional visual symptoms (i.e., photosensitivity, palinopsia, enhanced entropic imagery, and impaired night vision), two or more of which must be present for this specific diagnosis.\textsuperscript{4-11} Additional visual and non-visual symptoms are also frequently present (e.g., photopsia, tinnitus)\textsuperscript{4-11}. And, more recently, a wide range of non-strabismic, binocular vision/oculomotor dysfunctions have been found in approximately 60\% of those with VS/VSS that were clinically tested in a private practice optometric setting.\textsuperscript{8} Concussion/mild traumatic brain injury is the most common etiology.\textsuperscript{8} However, other etiologies include post-surgery with anesthesia and migraine, as well as being idiopathic in nature.\textsuperscript{8}

The symptom of VS was reported as early as 1944 related to intake of the medication digitalis for heart problems.\textsuperscript{12} However, over the two past decades, VS/VSS has received considerable attention regarding its defining characteristics, categorization, and diagnostic criteria.\textsuperscript{9-11} Much less attention has been devoted to its treatment, however, which has included medications,\textsuperscript{13} simple discussion of the problem to alleviate fears of it worsening,\textsuperscript{9} and the prescription of chromatic filters/tints.\textsuperscript{4-8,14}

While the prescription of chromatic filters/tints has received considerable recent attention, and with good success, there does not exist a comprehensive, standard protocol for its testing and prescribing.\textsuperscript{4-8} In the present paper, such a comprehensive testing and prescribing protocol for individuals with VS/VSS is proposed, along with their concurrent and common, non-strabismic binocular/oculomotor-based dysfunctions.

\section*{MATERIAL AND METHODS}

The proposed protocol was based on several sources of information. First, the extensive clinical and research experience of the authors over the past five years in this population. Second, on the shared experiences of our clinical colleagues over the same time frame in this population. Third, extensive searches of the literature via Pubmed, Google, Google Scholar, APA PsychNet, and Semantic Scholar over the past year, as well as other related papers and books. Keywords/phrases for the searches included: visual snow (VS), visual snow syndrome (VSS), chromatic tints in VS/VSS, oculomotor problems in VS/VSS, and diagnostic categorization/criteria for VS/VSS. Over 100 citations were found, with more than 20 being used and cited specifically in the protocol genesis.

\subsection*{VSS Comprehensive Vision and Binocular Vision Examination and Work-Up (Table 1)}

\textit{Detailed Case History}

In the patient with VS/VSS, a detailed case history is critical, especially with respect to its chronology and impact on quality of life. This would include vocational and avocational goals, as well as any behavioral adaptations to the condition (e.g., avoidance of reading due to the presence of palinopsia, restricted driving at night due to interference from the enhanced entoptic imagery and VS), and more. Careful probing as to the first
appearance of the VS, its basic characteristics, provocative conditions, prior treatment, medications taken, prior medical conditions (e.g., concussion) and any history of brain surgery/infection, and other possible factors that might be relevant, should be carefully and fully addressed.\(^7\)

In addition, three specific symptom-related questionnaires should be completed. These include the: (1) Visual Snow Syndrome Symptom Survey (VSSSS), which is specific for the diagnosis of VS/VSS.\(^4\) It covers patient demographics and some of the aforementioned case history aspects. However, and most importantly, it provides specification of the primary and secondary, visual and non-visual symptoms, and their severity using a rating scale of 0-2. This information is critical for a proper diagnosis; (2) Brain Injury Vision Symptom Survey (BIVSS),\(^15\) which addresses a broader range of areas of concern, including those of an oculomotor nature, as approximately 60% of these patients have been diagnosed with such problems.\(^8\) The questionnaire includes eight relevant subgroups of queries, such as reading, visual comfort, and diplopia. It contains 28 questions with a rating scale of 0-4; and (3) Visual Light Sensitivity Questionnaire-8 (VLSQ-8),\(^16\) which is a short, eight-item questionnaire specific for light sensitivity/photosensitivity, with a rating scale having five items to select (never to always). It probes such areas as frequency of light sensitivity, problematic light sources, and more. This information is useful to assess the area in general, as well as to determine the effect of some treatment, such as chromatic tinted lenses.

### Comprehensive Vision Examination

Following the detailed case history, the comprehensive vision examination is commenced. It encompasses three areas.\(^17\) The first is the refractive determination. This includes retinoscopy, autorefraction, and subsequent subjective refinement, all using a distance visual acuity test chart for fixational control and visual clarity comparisons. Near visual acuity should be assessed similarly. Keratometry might also be performed to estimate the corneal contribution of the astigmatic component to the overall refractive error. The second is the binocular/oculomotor assessment. This includes a range of tests: cover test (distance and near), near point of convergence, relative accommodation (near) and convergence (distance and near), stereoacuity, and global ocular motility (fixation, saccades, and pursuit). The third is determination of the ocular health of the anterior and posterior segments of the eye. For the former, tests include gross visual observation with a penlight and slit-lamp, gonioscopy, pupillary responses to light and accommodation (direct and consensual), and intraocular pressure. For the latter, it would include ophthalmoscopy (direct and binocular indirect), intraocular pressure, and color vision. Of course, other tests may be added at the discretion of the doctor.

### Additional Testing

Some additional testing may be helpful to understand the full spectrum of visual deficits in patients with VS/VSS. For example, both static and dynamic contrast sensitivity results have revealed increased thresholds for the perception of a grating in some patients under certain stimulus conditions.\(^18,19\) Similarly, conventional visual field testing has found abnormalities in approximately 15% of the patients tested.\(^20\) And, using a special stimulus paradigm, the pattern visual-evoked response findings have revealed small, subtle abnormalities: the N75-P100 amplitude was decreased, and the N145 latency was increased.\(^21\)

Due to the small sample sizes in some of these studies (e.g., n=7),\(^20\) and the subtlety of the deficits,\(^21\) these findings may be regarded
as somewhat preliminary in nature. Thus, it is suggested that the aforementioned probes be used in certain patients in which the information would be revealing and of benefit for a more complete understanding of the individual’s condition and its functional ramifications.

**Expanded Binocular Vision/Ocular Motility Work-Up**

Since many of these patients manifest non-strabismic, binocular/oculomotor vision dysfunctions (~60%), it would be important to conduct a specific directed work-up to further define/refine the diagnosis, and later to direct and target any therapeutic intervention (e.g., vision therapy, plus lenses at near). These typically include general oculomotor dysfunction (OMD), convergence insufficiency, accommodative insufficiency, convergence excess, and fusion with defective stereopsis. Since the typical patient with VS/VSS does not have either strabismus or amblyopia with greater frequency than found in the general population, this work-up would not include testing specific for either of these conditions. That would be a separate and special work-up if either condition were present.

There are several assessment tests that should be performed. These include:

1. Accommodative facility at near with +/-2.00D lens flippers, or those values age specific, to assess dynamics of accommodation.
2. Vergence facility at distance and near to assess dynamics of vergence.
   a. Distance: 2pd BI/4pd BO prism flippers
   b. Near: 4pd BI/12pd BO prism flippers
   c. Fusional ranges in free space employing stereo vectograms.
3. Near phoria assessment under dissociated conditions while performing a visual-motor guided task employing the Van Orden Star (VO).
4. Distance and near phoria assessment under dissociated viewing conditions using the Keystone ophthalmic telebinocular instrument in conjunction with visual skills cards.
5. Stereoacuity at near can also be determined with this instrument.
6. Near phoria and central suppression while performing a visual-motor guided task using a cheiroscopic tracing apparatus.
7. Sequencing of eye movements to different isolated letters with metrics including total time for completion and errors, and differentiating between a true oculomotor dysfunction and rapid automaticity naming via the Developmental Eye Movement Test (DEM).
8. Both horizontal and vertical eye movements for fixation, saccades, and pursuit tasks, as well as grade-based reading with detailed performance metrics using the objectively-based and automated RightEye System.
9. Horizontal eye movements for grade-based reading tasks with detailed performance metrics using the objectively-based and automated ReadAlyzer system.

**VSS Tint Assessment and Prescribing**

**Table 2: VSS Tint Assessment and Prescribing**

<table>
<thead>
<tr>
<th>1. Initial Tint Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Intuitive Colorimeter</td>
</tr>
<tr>
<td>b. Full spectrum of general ophthalmic tints</td>
</tr>
<tr>
<td>c. FL-41 and BPI-Omega tints</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Performance Specific Tint Selection, including vision therapy for any binocular/oculomotor dysfunction, with chromatic tint if deemed beneficial from the above testing.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Computer simulation of various environmental conditions</td>
</tr>
<tr>
<td>b. Natural surrounds (especially provocative ones)</td>
</tr>
<tr>
<td>c. Computer scrolling</td>
</tr>
<tr>
<td>d. Different illuminations</td>
</tr>
<tr>
<td>e. Long hallway with obstacles and signage</td>
</tr>
<tr>
<td>f. Follow-up: 1, 3, and 6 months</td>
</tr>
</tbody>
</table>

Once the diagnostic aspects are completed per Table 1, the tint assessment and prescribing commences (Table 2). This has two phases.
Phase 1

There are three components to phase one.

1. The first involves careful testing using the well-developed protocol of the Intuitive Colorimeter (IC) \(^6_{,}^{25}\) (Ceriumvistech.com) (Figure 2). Here the clinician can obtain a precision tint with respect to hue, saturation, and overall luminance transmittance. This evaluation requires 30-45 minutes for completion. Once these data are entered into the IC’s computer program, a specific lens or combination of lenses from the colorimeter’s trial set of 42 distinct tints is indicated. It can be ordered directly from the Cerium company in the U.K. The program also displays the lens’s wavelength-specific transmission, so the clinician can visualize directly the spectral range and relative magnitude of effect (Figure 3).

2. In the second component, and using the aforementioned specific tint from the IC as a chromatic reference point, the clinician can probe further using readily-available general ophthalmic tints within the same spectral range (chadwickoptical.com). These general tints are relatively inexpensive and are easy to order. If one or more of these general tints are selected (e.g., rose), the patient is then directed to assess its effect informally in various surrounds (e.g., office, computer screen), including the most provocative situation. Thus, both the IC tint, and related ones, are tested for effectiveness of reducing the VS under several naturalistic conditions.

3. In addition, the clinician may explore the effects of the FL-41 (eschenbach.com,
Hence, under optimal conditions, the VS/VSS patient has a relatively wide array of tint selections available to assess subjective reduction of the VS, and in some cases the related abnormal perceptual phenomena such as the palinopsia and photosensitivity.

**Phase Two**

With the aforementioned selection of chromatic tints, testing can be yet more specific, if desired. This would include a more formal assessment using a continuous rating scale of 0-100% (i.e., none to all) with respect to perceived reduction of the VS. The patient is now exposed to various other visual scenarios, as at times more than one tint may be necessary to prescribe (e.g., one for general usage and one specific for computer viewing). These test conditions would include:

1. Computer simulation over a wide range of possible indoor and outdoor visual scenes, where density, grain size, and velocity of the simulated VS can be adjusted (visionsimulations.com).
2. Computer scrolling using large and small screens, as well as on a smartphone.
3. Different illuminations, as the VS can be more intrusive and noticeable/revealing for one condition versus others (e.g., normal room illumination versus night time driving).
4. Walking along a long hallway containing several large and small obstacles, as well as signage that needs to be read as it is approached.

Once the final tint is ascertained, any abnormal aspects of the earlier binocular vision work-up should be repeated. It is possible that presence of the dynamic VS can function as a source of visual interference and introduce an accommodative error (e.g., the Mandelbaum effect which disturbs accommodation). For example, attempting to quantify the amplitude of accommodation and accommodative facility in the presence of VS produces competing and overlapping visual scenes, as well as acting as an attentional distractor with increased response error. Thus, the chromatic filter may actually have two important effects: reduce the VS per se and reduce its visual interference on visual performance. Anecdotally, we have found this to be the case in some patients (~20%). Once this is ascertained, vision therapy for any documented binocular/oculomotor deficit can be initiated using conventional, well-established protocols. This can be performed with the therapeutic tint in place, if deemed beneficial, to reduce the VS interference and enhance binocular function.

Once the final tint is selected, it can be prescribed in either spectacle or clip-over form. The patient should return to the clinic for follow up at 1, 3, and 6-month intervals to assess its continued efficacy. It is possible that tint effectiveness may reduce over time due to a neural chromatic adaptation effect. If this occurs, the tint selection needs to be reevaluated.

**DISCUSSION**

We have proposed the first formal clinical protocol for the comprehensive diagnostic assessment and treatment of the patient with VS/VSS using a neuro-optometric approach. While a recent study proposed a treatment protocol for oculomotor/motor/visual processing deficits, it did not include a tint component nor the possible interaction of the tint on oculomotor/motor/visual processing aspects. The present protocol has two distinct components:

1. The vision assessment including a range of sensory, binocular, oculomotor, and perceptual aspects, and
2. The tint assessment and related prescribing including any binocular/oculomotor component.

Since this is the first protocol of its type, there will be revisions over time as others use it and add their own specific tests based on experience. Furthermore, as new discoveries and advances...
are made in the field, related changes would likely occur.

In addition to the prescribing of a tint in spectacle form to alter the visual chromatic and luminance transmittance to the eye, one can also alter certain limited aspects of the environment. This would include the computer screen and smartphone display, both of which are so prevalent in modern society. In one recent case report, the patient had restricted use of their prescribed (“green”) chromatic tinted spectacles by her employer. To circumvent this problem, at least in part, she readily altered her smartphone’s display screen chromatic and luminance characteristics to approximate those of the spectacles, with ease and resultant visual comfort. The same can be done with one’s computer screen display. In addition, if certain types of illuminations (e.g., fluorescent lighting) exacerbate the VS, then such an environment can either be avoided, or at home the luminaires can be changed to be less visually offensive. Other modifications might be attempted, such as painting rooms in the house with colors that are not provocative with respect to presence and persistence of the visual snow.

The clinical researcher and basic optics designer should collaborate to develop chromatic tints that reduce the VS without resulting in much reduction of overall visual field luminance and distortion of one’s color perception. One such design is the use of narrow-band spectral filters. Typical clinical chromatic filters reduce, at least to some extent, a relatively wide range of wavelengths in the visible spectrum (e.g., 100+ nm) and overall visual field luminance. In contrast, with a narrow-band, “notch” filter design, the offensive wavelengths would be markedly reduced in transmittance, perhaps over a range of only approximately 20nm, with the remainder of the visible spectrum left unaltered. This is a fruitful area of future optical design exploration.

To understand better the condition of VS/VSS, and hence any therapeutic intervention, laboratory testing in two areas would be beneficial; visual psychophysics, and electrophysiological brain testing (e.g., VEP) and fMRI or BOLD brain imaging. With the former, one could probe chromatic mechanisms to determine presence of any abnormalities as well as possible chromatic adaptation effects that might affect chromatic filter acceptance and long-term efficacy. With the latter, the brain itself can be non-invasively probed using a range of potentially provocative stimuli to ascertain regions of responsivity, as well as their response magnitude and/or processing delays, with and without the precision tint. This is fertile territory for the basic researcher.

REFERENCES


AUTHOR BIOGRAPHY:
Daniella Rutner, OD, MS, MBA, FAAO, FCVO, Dipl (ABO)
SUNY College of Optometry,
New York, New York, USA

Dr. Daniella Rutner is an Associate Clinical Professor at the SUNY College of Optometry and the Chief of Vision Rehabilitation at the University Eye Center. She received her bachelors in education from Brooklyn College, CUNY and earned both her Doctor of Optometry and Masters of Vision Science degrees from SUNY College of Optometry in 2002. Dr. Rutner attained her fellowship in the American Academy of Optometry (AAO) in 2004 and the College of Optometrists in Vision Development (COVD) in 2007. In 2013, she received her diplomate in the American Board of Optometry (ABO). In 2018, Dr. Rutner received the Optometrist of the year award from the New York State Optometric Association. She has published several peer-reviewed articles and book chapters. Dr. Rutner continues to be involved in teaching, clinical care and clinical research.