

## Brief Communication

# Headache and Dizziness after Roller Coaster Rides: A Case Series of 31 Patients

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**ABSTRACT:** Previous literature on roller coaster injuries focuses on catastrophic injuries. We conducted a retrospective study of 31 adults with headache or dizziness after roller coaster rides. Twenty five of 31 (81%) patients presented with new or worsening headache, predominantly migraine (15/25, 60%), including 8/25 (32%) with chronic migraine. Of the chronic migraine patients, 4/8 (50%) already had the diagnosis and presented with an exacerbation. Five of the 25 (20%) were ultimately found to have a cerebrospinal fluid (CSF) leak. While persistent symptoms appear to be relatively rare, patients with chronic migraine and potential CSF leaks should consider skipping these attractions.

**RÉSUMÉ :** Céphalées et étourdissements après un tour de montagnes russes : série de cas de 31 patients. Il fut un temps où la documentation médicale portant sur les blessures causées par les tours de montagnes russes faisait surtout état de cas de blessure gravissime. De notre côté, nous avons mené une étude rétrospective chez 31 adultes ayant ressenti des céphalées et des étourdissements après un tour de montagnes russes. Sur ce nombre, 25 patients (81 %) avaient consulté pour des céphalées nouvelles ou des céphalées plus intenses qui, la plupart du temps, se présentaient sous forme de migraine (15/25; 60 %), devenue chronique chez 8 d'entre eux (32 %). Parmi ces derniers patients (8), un diagnostic de migraine chronique avait déjà été posé chez 4 d'entre eux (50 %), qui consultaient pour des crises. Par ailleurs, une fuite de liquide céphalorachidien (LCR) a finalement été observée chez 5 patients sur les 25 (20 %). Enfin, bien que la persistance des symptômes semble relativement rare, les patients souffrant de migraine chronique et ayant des fuites possibles de LCR devraient éviter ces jeux.

**Keywords:** Roller coaster; Chronic migraine; Post-traumatic headache; Dizziness; CSF leak

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In 2019, the world's top 10 theme parks received 521.2 million visits.<sup>1</sup> Many feature ever taller and faster roller coasters with the current record holders “Kingda Ka” at Six Flags Great Adventure reaching 456 feet tall and “Formula Rossa” at Ferrari World Abu Dhabi achieving 149 miles per hour.<sup>2</sup> Previous case reports of injuries associated with roller coasters have predominantly focused on catastrophic injuries such as internal carotid and vertebral artery dissections with cerebral infarctions as well as subarachnoid hemorrhages, but have largely overlooked new or worsening headaches and dizziness not associated with devastating injury.<sup>3–5</sup>

The International Classification of Headache Disorders, Third Edition (ICHD-3) defines headache attributed to trauma or injury to the head and/or neck by a new headache occurring for the first time in close temporal relation to trauma or injury to the head and/or neck and when a preexisting headache with the characteristics of a primary headache disorder becomes chronic or is made significantly worse in close temporal relation to trauma or injury.<sup>6</sup>

Post-traumatic headaches most commonly present with a migrainous phenotype in 88% of respondents according to one study, with 91% of patients developing new headaches in the absence of a previous headache disorder.<sup>7</sup> It is also notable that although chronicification in migraine is a process which may take years, persons with post-traumatic headache may develop chronic headaches rapidly, sometimes within weeks to months after injury.<sup>8</sup>

Therefore, given the sheer volume of people who ride roller coasters in a given year and that head or neck injuries can be a risk factor for chronic headaches, understanding non-catastrophic injuries as a result of roller coaster rides is important in allowing thrill seekers to safely engage in these activities.<sup>9</sup> Our study examines a group of patients with new or worsening headache or dizziness after riding a roller coaster.

We conducted a retrospective chart review of 31 adults, approved by the Stanford Internal Review Board (IRB), for demographics, medical and headache history. Participants were evaluated by the outpatient Stanford Neurology Department providers

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**Table 1:** Summary of included cases of headache and dizziness after roller coaster rides.

Age at Incident	Sex	Race	Prior Medical History	History of Trauma	Time to onset of Symptoms	Post-Roller Coaster Diagnosis
49	Male	Hispanic	Chronic Migraine	None	Immediate	Headache secondary to tumor
31	Female	White	Primary Generalized Epilepsy	Prior concussion and whiplash injury	Immediate	Post-traumatic headache
33	Female	Hispanic	None	None	Months	Occipital Neuralgia, Migraine
40	Female	Hispanic	Chronic Migraine	None	Within one week	Chronic Migraine
44	Male	White	None	None	Immediate	Episodic Dizziness
22	Male	White	None	None	Immediate	Post-traumatic headache with chronic migraine phenotype
23	Male	Unknown	None	None	Immediate	Occipital Neuralgia
Early 20s	Female	White	None	None	Immediate	Episodic lightheadedness
36	Female	Hispanic	Episodic Migraine	None	Immediate	Episodic migraine
23	Female	White	Episodic Migraine	None	Immediate	Post-traumatic headache with chronic migraine phenotype
41	Female	White	None	None	Less than one month	Mal de débarquement vs. vestibular migraine
40	Male	Asian	None	None	Immediate	BPPV
43	Female	White	None	Prior whiplash injury	Within one week	CSF Leak
47	Female	White	Chronic Migraine	None	Within one week	Chronic Migraine
32	Female	White	Episodic Migraine	None	Immediate	Episodic Migraine
38	Female	White	Episodic Migraine	Prior whiplash injury	Within one week	Occipital Neuralgia
33	Male	White	Chronic Migraine	None	Months	Chronic Migraine
28	Female	White	Thalamo-mesencephalic tumor with mild hydrocephalus s/p third ventriculostomy, major depressive disorder, generalized anxiety disorder, chronic migraine	None	Immediate	Vestibular Migraine
18	Female	White	Episodic Migraine	None	Within one week	Chronic Migraine
43	Female	White	None	None	Immediate	Chronic axial neck pain, myofascial pain
25	Male	Asian	None	Prior whiplash injury	Immediate	Post-traumatic headache with chronic tension-type phenotype
28	Female	White	Episodic Migraine	None	Immediate	Chronic Migraine
18	Female	White	Chronic Migraine	Prior concussion and whiplash injury	Immediate	Chronic Migraine
24	Female	Asian	None	None	Immediate	CSF Leak
41	Female	Unknown	Chronic Daily Headache	Prior whiplash injury	Immediate	CSF Leak
23	Female	White	Headache attributed to Spontaneous Intracranial Hypotension s/p Blood patch for cerebrospinal fluid Leak	None	Immediate	CSF Leak
20	Female	Asian	Episodic Migraine	None	Immediate	Episodic Migraine
49	Male	White	Primary Cough Headache	None	Immediate	Primary Cough Headache
30	Male	White	None	Prior concussion	Immediate	Episodic Migraine, BPPV
35	Female	White	Chiari 1 Malformation, EDS	Prior concussion	Immediate	Neck pain
44	Female	White	Chronic Daily Headache	None	Immediate	CSF Leak

between January 1, 2015 and May 16, 2022. Clinical documentation in the medical charts was obtained by individual neurology attendings during new and follow-up patient visits from direct patient interview. Written informed consent was waived by the IRB based on the exclusion of HIPAA identifiers. Charts were requested

through the secure Stanford Research Repository Tool (STARR) software with the following inclusion criteria: age equal to or greater than 18, seen between January 1, 2015 and May 16,2022, evaluated under the electronic health record context “NEURO AT HOOVER,” where the term “roller coaster” or “rollercoaster” appeared in the

chart. The initial search yielded 636 charts for review, which were then deidentified. Charts were individually reviewed and excluded if they did not meet inclusion criteria or if the use of “roller coaster” or “rollercoaster” was incidental. We identified 34 participants in this search. Three additional patients were then excluded, two with recurrent seizures and one with temporary loss of consciousness after roller coasters, given the focus on headache and dizziness for this review. This is the primary analysis of these data. Missing data included the unknown ethnicities of two patients and one unknown age at the time of roller coaster ride.

Descriptive statistics were calculated within Microsoft Excel including frequency, percentage, mean, standard deviation.

A summary of the 31 cases of new or worsening headache or dizziness after riding a roller coaster appears in Table 1. Our study population had an average age of  $33.4 \pm 9.4$  years old and the majority were female, 22/31 (71%). Twenty-one (68%) were Caucasian and an additional four each (13%) were Asian or Hispanic with two (7%) not having a reported ethnicity.

An antecedent history of any headache was present in 17/31 (55%) and 13/31 (42%) had a history of migraine including either episodic migraine in 7/31 (23%) or chronic migraine in 6/31 (19%). One patient had a previous history of primary cough headache (1/31, 3%), and another patient had a history of headache attributed to spontaneous intracranial hypotension due to a cerebrospinal fluid leak that had been successfully treated with a blood patch (1/31, 3%). An additional two patients carried a diagnosis of chronic daily headache that had not been more specifically diagnosed and in whom a retrospective diagnosis could not be made with the information available in the chart. A prior history of concussion or whiplash was present in 8/31 (26%).

The primary presentations of headache after riding roller coasters included worsening headache in 11/31 (36%) and new onset headache in 8/31 (26%). Dizziness after roller coasters included new onset dizziness in 5/31 (16%) and worsening dizziness in 1/31 (3%). Two patients (7%) noted new neck pain.

Four additional patients (13%) reported roller coasters as a known exacerbating factor for their previously diagnosed migraine.

Time to onset of headache or dizziness was immediate in 23/31 (74%) and within one week in an additional five patients (5/31, 16%). Only 3/31 (10%) had onset after more than one week.

Of the 25 patients with new or worsening headache, 15/25 (60%) met ICHD-3 criteria for migraine including 8/25 (32%) who met criteria for chronic migraine. Notably, of these eight patients with chronic migraine, 4/8 (50%) previously had a diagnosis of chronic migraine, 3/8 (38%) had a history of episodic migraine, and only 1/8 (13%) had no history of migraine.

Of the 6/31 (19%) patients with new or worsening dizziness, 2/6 (33%) were diagnosed with benign paroxysmal positional vertigo (BPPV). The remaining four patients were reported to have episodic dizziness, and a more formal diagnosis was not made at the time and could not be made retrospectively.

Notably, 5/25 (20%) patients with new or worsening headache ultimately met ICHD-3 criteria for headache attributed to spontaneous intracranial hypotension due to a cerebrospinal fluid (CSF) leak. Of these five patients, 2/5 (20%) had a history of chronic daily headache that was being evaluated for a more definitive diagnosis, and two others had no history of headache. One patient had a history of a CSF leak, successfully treated with a blood patch, that recurred after the roller coaster ride.

Given the large volume of people who enjoy roller coasters annually, we suspect that persistent headache and dizziness after roller coasters are relatively rare, with only 31 cases identified

within the cases seen by the outpatient neurology department over seven years.

Previous reports of more severe injuries on roller coasters have attributed the damage to excessive peak G forces, a measure of acceleration; however, motor vehicle accident research has indicated that peak G forces are unlikely to cause these injuries as they are well under the maximum tolerated for humans given the brief intervals over which they are experienced.<sup>10</sup>

Certain trends in this small cohort were notable and warrant attention for specific patient demographics and future studies. Of the six patients with chronic migraine prior to riding a roller coaster, 4/6 experienced exacerbation of their migraine, one had new onset occipital neuralgia, and one had an exacerbation of their headaches which led to the discovery of a sphenoidal meningioma that was potentially contributing to their headache. It would consequently be reasonable to counsel patients with chronic migraine that roller coasters may lead to exacerbations of their headache. Additionally, roller coaster rides may not be recommended for patients with a history of CSF leak, have conditions known to predispose increased risk for CSF leak such as connective tissue diseases, or with chronic daily headaches who are being evaluated for CSF leaks. Caution may also be suggested to patients with a prior history of concussion or whiplash, as at least one of these was present in 8/31 patients.

Limitations of the study were mainly due to the location of the study and its small sample size. The San Francisco Bay Area is home to two modest sized amusement parks with notable roller coaster collections; however, neither of these is in close proximity to the Stanford Health Care Palo Alto campus. It is quite plausible that significantly more cases of new or worsening headache or dizziness would be found in studies conducted in closer proximity to those parks, or larger amusement parks hubs such as Southern California or Orlando. The number of cases seen was also likely limited by the Stanford Neurology department being a tertiary care center with a focus on complex or refractory cases and many cases may not have advanced past the patient's primary care physician or local neurologist. Additionally, because of the small sample size and retrospective nature, the contribution of the number of roller coasters ridden or specific elements of the roller coasters such as speed, height of drops, acceleration, and inversions could not be evaluated.

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