Nickel and cobalt release from fidget spinners on the Danish market

Malin G. Ahlström[1], Jacob P. Thyssen[1], Torkil Menné[1], Morten S. Jellesen[2], Peter J. S. Westermann[2] and Jeanne D. Johansen[1]

[1]*Department of Dermatology and Allergy, National Allergy Research Centre, Herlev and Gentofte Hospital, University of Copenhagen, 2900, Hellerup, Denmark and* [2]*Department of Mechanical Engineering, Technical University of Denmark, 2800, Kgs. Lyngby, Denmark*

doi:10.1111/cod.12924

Key words: children; cobalt; contact allergy; fidget spinners; nickel.

Fidget spinners, which are toys used by children of school age, became very popular in 2017. During normal use, they are in direct and prolonged contact with the skin on the hands. Fidget spinners may have metals parts, and therefore represent a potential source of metal contact allergy and thus allergic contact dermatitis. The aim of this study was to screen a random selection of fidget spinners on the Danish market for nickel and cobalt release.

Methods

In July to August 2017, M.G.A. purchased, avoiding duplicates, 41 random fidget spinners from a wide variety of stores: toy stores (n = 10), on the internet (n = 10), accessory stores (n = 9), markets (n = 4), bookshops (n = 2), Danish discount design chains (n = 2), a greengrocer (n = 1), a supermarket (n = 1), a sports shop (n = 1), and a piercing and tattoo studio (n = 1). In total, we spent €440, and the price varied from €2.7 to €23. The dimethylglyoxime (DMG) test and the cobalt spot test were used for screening of nickel and cobalt release, respectively (1, 2), as previously described (3), in our laboratory at the Department of Dermatology and Allergy. The DMG result was classified as positive (pink), negative (no colour change), or doubtful (discolouration other than pink). All locations with doubtful reactions were retested: a remaining doubtful test reaction was classified as doubtful. The cobalt spot test was performed before the DMG test to decrease the risk of false-positive reactions (1). The fidget spinners were placed on a non-woven swab (Curi-Med; Abena, Aabenraa, Denmark), ~50 ml of cobalt spot test solution was poured over them, and the result of the test was read after ~20 min. Also, metal parts that were not considered to be in direct contact with the swab were tested with one drop of the cobalt spot test solution on a cotton stick and rubbed for 30 seconds (1). The test result was classified as positive (orange–red), negative (yellow), or doubtful (light brown to rust-like). If the cobalt spot test had resulted in a colour change, the fidget spinner was rinsed with tap water before DMG testing.

Qualitative analysis with X-ray fluorescence (XRF) (Maxxi 6, 2016, S/N 21G1627; Oxford Instruments, Taunusstein, Germany) was performed on 10 spinners with a positive or doubtful spot test reaction, or with a green discolouration with the cobalt spot test, at the Technical University of Denmark. One aluminium-containing spinner was analysed with a TM3000 Tabletop Microscope (Hitachi, Tokyo, Japan) equipped with a Bruker (Berlin, Germany) Nano energy dispersive spectroscopy (EDS) detector (product ID 2107; Serial no.: 0357). All metallic sites considered to be in direct contact with the hands, that is, the centre pad (where fingertips are placed) (Fig. 1b), the wings (arms) (Fig. 1b), and the outer bearings of the wings (Figure S1b), were tested. Also, the centre ball bearing (under the centre pad) (Figure S1a) was tested, as it was made of metal. Parts that were visibly made from plastic were not tested.

Results

Spot test results are shown in Table S1, and qualitative analyses of 10 spinners are shown in Table S2. The DMG test gave a positive result for one (3.6% CI: 0.2–20.2), and doubtful results for two (7.1% CI: 1.3–25.0) of 28 tested centre pads. EDS of the DMG-positive centre pad verified a content of 0.9% nickel, and XRF analysis

Correspondence: MD Malin Glindvad Ahlström, Department of Dermatology and Allergy, National Allergy Research Centre, Herlev and Gentofte Hospital, University of Copenhagen, DK2900 Hellerup, Denmark. Tel: +45 38677310.
Email: malin.glindvad.ahlstroem.01@regionh.dk

Conflict of interests: None of the authors declare any conflict of interests pertinent to the present article.

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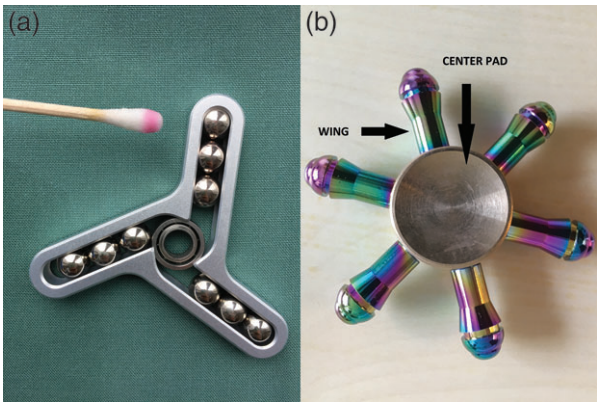


Fig. 1. **(a)** A positive dimethylglyoxime test reaction for the metallic balls of the wings of a fidget spinner. Qualitative analysis indicated that they are nickel-plated steel balls. **(b)** Photograph of a spinner with high concentrations of lead in the centre pad and in the wings.

of the two doubtful DMG spot test reactions showed contents of 0.5% and 4.7% nickel, respectively. None of the centre pads were positive for cobalt. Unexpectedly, two of the centre pads contained high amounts of lead (Table S2).

Three spinners had DMG-positive wings (Fig. 1a), and additional qualitative analysis of these spinners confirmed high nickel contents (36.6–43.5%). One outer bearing of the wing had a doubtful DMG spot test reaction, but was found not to contain nickel by XRF. Qualitative analysis of the DMG spot test-negative wings of one spinner showed that it contained brass with a plated layer of nickel, and then a physical vapour deposition-coated layer of titanium (Fig. 1b). A cross-section through the wings of this spinner showed that it also contained lead. Qualitative analysis of the wings of one spinner with a doubtful cobalt spot test result confirmed that it contained 0.8% cobalt. Also, eight fidget spinners gave positive results with the DMG spot test at the centre ball bearing, a site that is probably rarely in direct contact with the skin (Table S2).

Different nuances of brown (light brown to rust-like) emerged with the cobalt spot test for 19 spinners. The light brown nuances appeared when the metal contained copper or nickel (Figures S1c and S2c). The darker brown colour from one spinner was caused by rust formation (Figure S1b). Also, green discolouration with varying intensity appeared in 33 of the 41 fidget spinners, corresponding to metal parts (Figures S1a–c and S2c). Qualitative analysis showed a high content of iron corresponding to these parts (Table S2). The green and brown colour originated from the same metal parts of several spinners (Figure S1b).

Discussion

In this study of 41 fidget spinners, we found nickel release as determined with the DMG spot test from four and cobalt release as determined with the cobalt spot test from none of the metallic parts expected to come into contact with the skin during normal play. Further qualitative analysis confirmed nickel content (0.9–43.5%) in the four DMG-positive spinners, and on the surface of one centre pad with a doubtful DMG spot test result (4.7%). Cobalt was found at a level of 0.8% on the surfaces of the wings of one spinner. Nickel release was detected both from centre pads, which are in direct contact with the skin during play, and from the wings, which we expect to have some skin contact.

Qualitative analysis of a selection of 10 spinners showed the use of chromium and lead in some spinners. A lead content of 1.4–2 wt% was found in two centre pads and in the wings of one spinner, and was probably intentionally added, as it is known to ease brass machinability. The DMG spot test gave a positive result for one centre pad that was found to be mainly composed of aluminium. A thin layer of nickel remaining on aluminium after surface treatments has previously been described for products such as computers (4, 5).

The cobalt spot test is relatively new (1), and interference by other metals or materials has been reported (6, 7, 8). In this study, we found green and/or rust-like discolouration in metal parts with high iron contents, and light brown discolouration caused by nickel or copper. Our results confirm the usefulness of the cobalt spot test; however, because of the risk of misinterpretation resulting from rust formation or interference by other released metal ions, it is important to also perform follow-up studies of spot test analysis with quantitative and qualitative analysis techniques such as XRF analysis.

We conclude that some fidget spinners may induce nickel allergic contact dermatitis after prolonged contact with the skin.

Acknowledgements

The authors would like to thank multimedia designer Anna Bünning Olsson for assisting with the setup of figures.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Figure S1. (a) Cobalt spot test of the centre ball bearing resulting in green discolouration, believed to be caused by iron release. Qualitative analysis showed

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chromium-containing iron alloy, indicating that the ball could be made of DIN 100Cr6 – a conventionally used ball bearing steel type. **(b)** Cobalt spot test resulting in green and rust-like discolouration (also shown on a cotton stick) of the metal parts of three outer bearings of the wings. Qualitative analysis confirmed high amounts of iron being present. **(c)** Cobalt spot test resulting in light brown discolouration from the centre pad (removed), believed to be caused by copper ion release, as the qualitative analysis suggests the centre pad to be made of brass.

Figure S2. (a) A fidget spinner before dismantling. (b, c) Metal balls from the wings are nickel-plated iron balls that were positive with the DMG spot test **(b)** and light brown with the cobalt spot test **(c)**. Also, the centre ball bearing and the metal of the three outer bearings of the wings resulted in green discolouration.

Table S1. Spot test results.

Table S2. Full test result list for 10 fidget spinners, tested by DMG and cobalt spot test and XRF analysis.

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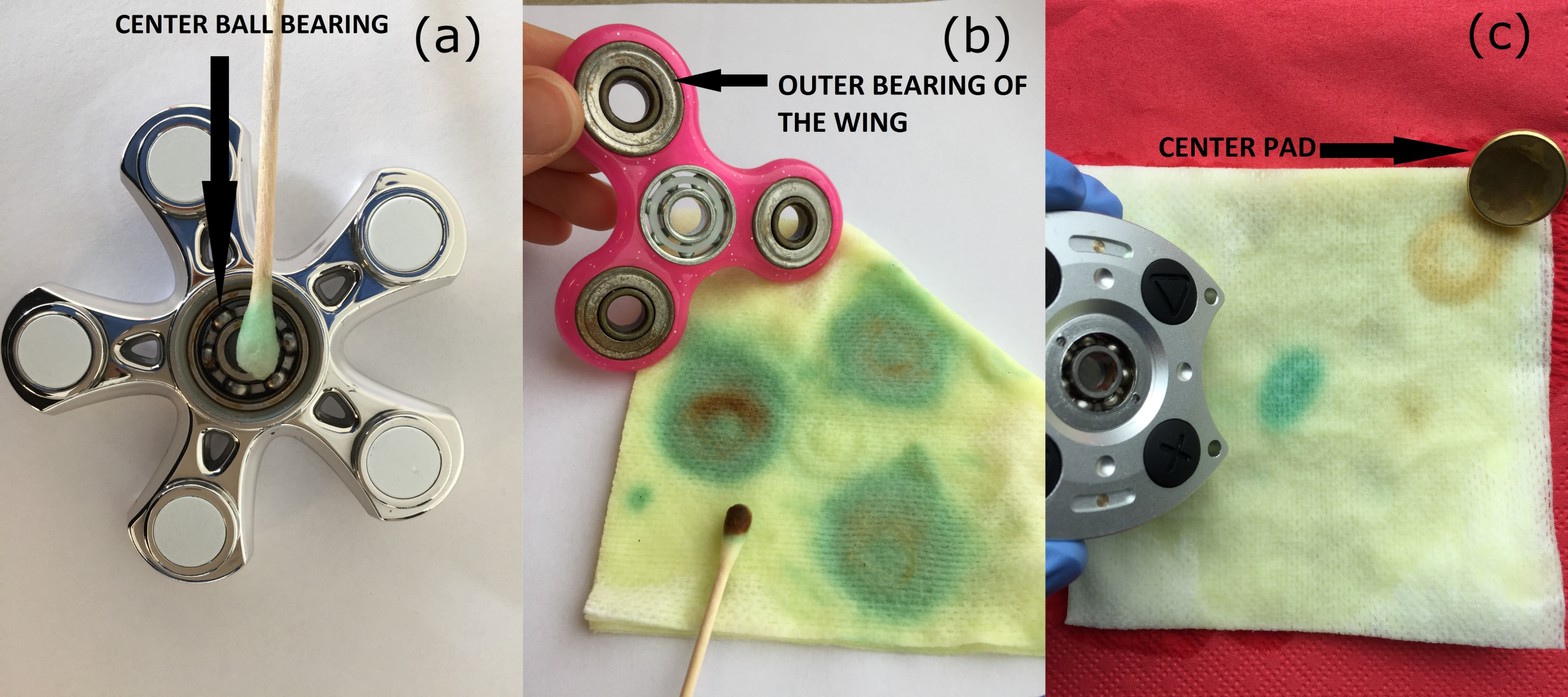
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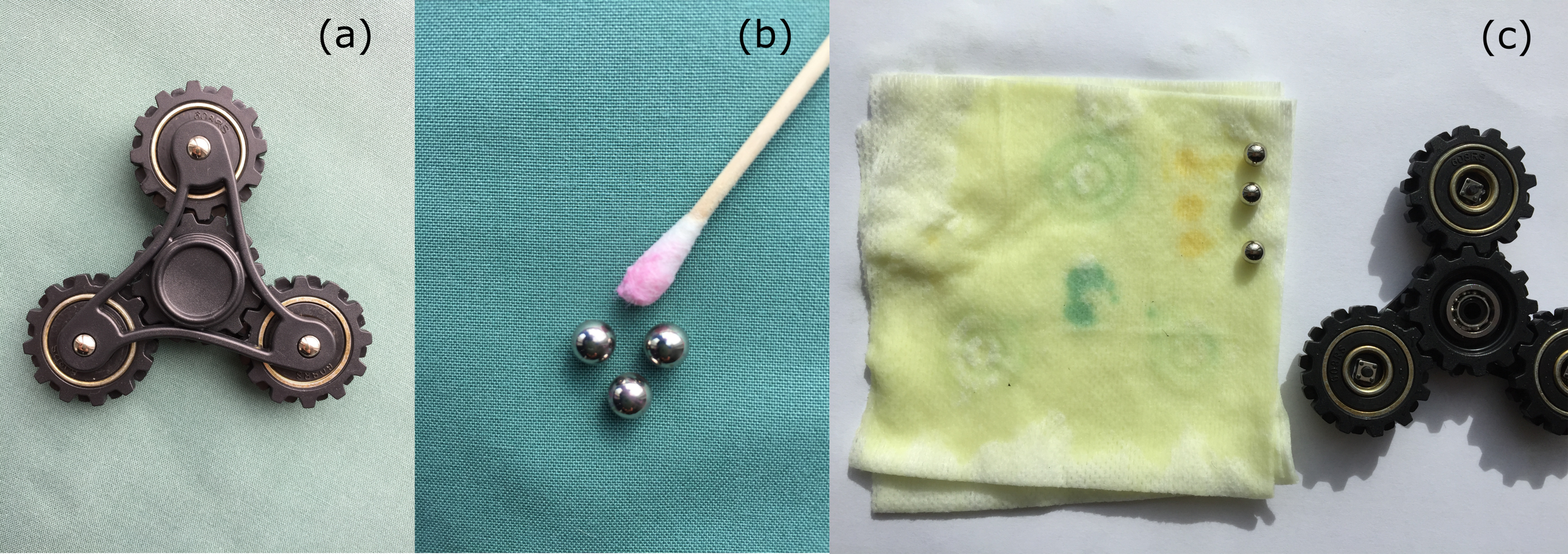
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CENTER BALL BEARING
(a)
(b)
OUTER BEARING OF THE WING
(c)
CENTER PAD


(a)
(b)
(c)