Elemental and microstructural analysis of fake, real, and standard orthodontic brackets

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Abstract. The increasing demand for orthodontic treatment in the Malaysian community has led to the development of “fake” and “real” braces. Fake and real braces have been offered through social media by unqualified personnel using poor quality orthodontic brackets. Notably, cases of metal toxicity from these braces have been reported. Here, we explored the composition and microstructure of several types of fake, real, and standard (professional) braces. A total of nine upper right central incisor brackets were examined using high-resolution scanning electron microscopy equipped with an energy-dispersive X-ray spectrometer to analyze the composition and evaluate the surface morphology of each bracket. Surface textures of the fake and real braces were noticeably more granular and unpolished than those of standard orthodontic brackets. All fake and real bracket designs were distinctly inferior from standard upper right central incisor brackets. All brackets were manufactured from different types of alloys; however, none contained any harmful elements.

1. Introduction
Orthodontic braces are currently considered a fashion accessory and a symbol of wealth in Southeast Asia. The demand for braces is overwhelming, not only from teenagers but also from adults. Thus, the terms “fake” and “real” braces have come into use. “Fake” braces are fashion accessories and are not bonded to the teeth; the brackets are attached to the wire with orthodontic elastics and the wire is bent at the end and is inserted in between the molars. Thus, fake braces do not produce any tooth movement. However, “real” braces are bonded to the teeth and can cause tooth movement. Both fake and real braces are provided by unqualified practitioners in unlicensed premises in locations like hotel rooms or customers’ homes. These practitioners are laymen who have never received formal dental education, often learning about braces through online videos. They advertise their services through social media sites, such as Facebook or Instagram, and deliver services at very low cost.

Risks of wearing such types of braces include swallowing of the appliance, pain, loss of periodontal support, infection from non-sterile equipment, and lead poisoning. These hazards have been reported in
Thailand, and the causes of deaths of two teenagers were linked to such braces. Conversely, “standard” braces are manufactured by medical device manufacturers and are widely used by licensed orthodontic specialists at dental clinics or hospitals. These brackets are extensively tested for their safety and efficacy for producing the desired tooth movement [1-5].

Currently, there are no existing studies that have systematically investigated fake and real braces. As such, we have little information on their composition and detailed features. Therefore, this study aimed to inspect and compare the composition, design, and surface microstructure of different types of fake, real, and standard orthodontic brackets.

2. Methods
A total of 9 samples of upper right central incisor brackets were obtained from several sources (Table 1). Samples 1–3 were fake brackets, 4–6 were real brackets and these samples were obtained from various unauthorized suppliers from social media. Samples 7–9 were standard brackets that were purchased from authorized medical and dental suppliers. The elemental and surface design of each bracket was analyzed using a scanning electron microscope (SEM) equipped with an energy-dispersive spectroscopic detector (SEM FEI Quanta 450, Oregon, USA). The voltage was 30 kV, and the electron beam resolution was 3.0 nm at 25 kV. Images were obtained at 65×, 500×, and 1000× magnifications. Quantitative analyses were performed using the AZtecEnergy software (Oxford Instruments PLC).

| Sample no. | Braces Type         | Manufacturer                      |
|-----------|---------------------|-----------------------------------|
| 1         | Fake braces 1       | No brand                          |
| 2         | Fake braces 2       | No brand                          |
| 3         | Fake braces 3       | No brand                          |
| 4         | Real braces 1       | No brand                          |
| 5         | Real braces 2       | No brand                          |
| 6         | Real braces 3       | No brand                          |
| 7         | Standard braces 1   | 3M Victory Series™               |
| 8         | Standard braces 2   | Forestadent Quick®               |
| 9         | Standard braces 3   | MEM Dental EPS                    |

3. Results and Discussion
3.1 Metal composition
Energy-dispersive spectroscopic analysis revealed that each bracket was manufactured from different types of alloys mainly iron, chromium, copper, nickel and carbon (Figure. 1). The difference in metal composition between “fake”, “real,” and standard braces was assessed using analysis of variance (Table 2), which revealed no significant difference in the composition of the three types of brackets (P = 0.633). It is important to note that the alloy composition can affect the biocompatibility, corrosion resistance, and ionic release of orthodontic appliances [6]. A study conducted by Huang et al. (2004) showed that metal brackets can corrode in the oral environment and that metal ions can leach out of the brackets [7]. Numerous studies have reported that some heavy metals are teratogenic and mutagenic even at low doses. Besides, heavy metals can also cause behavioral and neurological disorders in infants and children [8-10]. Here, we investigated the presence of the three most common heavy metals present in dental brackets: lead (Pb),
mercury (Hg), and arsenic (As) (Figure 1). While these metals were not detected in all samples, we only tested three samples from each group; hence, the results should be interpreted with caution.

![EDS analysis of fake, real and standard orthodontic brackets.](image)

**Figure 1.** EDS analysis of fake, real and standard orthodontic brackets.

| Source of Variation | SS   | df | MS     | F    | P-value |
|---------------------|------|----|--------|------|---------|
| Between groups      | 1602.132 | 8  | 200.267 | 0.767| 0.633   |
| Within groups       | 17242.500 | 66 | 261.250 |      |         |
| Total               | 18844.630 | 74 |         |      |         |

Statistically significant difference at $P < 0.05$. (SS: sums of squares; df: degree of freedom; MS: mean square).

### 3.2. Bracket design
The design of all fake brackets differed from that of standard orthodontic ones. Of all fake and real braces, only the brackets from the real braces #2 sample (sample 5, Table 1) resembled a standard orthodontic bracket in terms of bracket’s shape and size (Figure 2). The design of brackets from the fake braces #3 and real braces #1 samples (samples 3 and 4) were similar to that of lower incisor brackets. The bracket tip prescription was not visible on any of the fake and real braces (samples 1–6), except for in the real braces #2 sample (sample 5). Samples 7 and 9 were standard orthodontic brackets, whereas sample 8 was a self-ligating bracket; these brackets have a distinctive feature of an upper right central incisor bracket with the
evidence of tip prescription. All standard orthodontic and real braces #2 brackets had markings on the upper left corners for identification.

Standard orthodontic brackets have distinct designs for each tooth. Each bracket is constructed to conform to the size and morphology of the crown surface. The standard brackets studied here showed the characteristics of an upper right central incisor bracket, although all three of them were from different manufacturers. Conversely, the design of the fake and real brackets was inconsistent and substandard. For example, some of the upper central incisor brackets were small and resembled lower incisor brackets.

The fake and real braces also lacked bracket prescriptions. All standard orthodontic brackets have tip and torque prescriptions built into the brackets. This is evident from the angulated slot for the mesio-distal tip and torque expression from the base of all standard brackets. According to Andrew’s six keys to normal occlusion, tip and torque prescriptions allow for correct positioning of the crown and root of each tooth [11]. This is not a major concern for fake braces because they are not bonded to the teeth. However, real braces with improperly designed brackets can incorrectly position the crowns and roots of teeth within the alveolar bone, possibly causing detrimental adverse effect including periodontal problems in the future. Periodontal diseases associated with orthodontic treatment have been well documented, and complications include root resorption, dehiscence, and gum recession [12-15].

Figure 2. Scanning electron microscopy of bracket samples 1–9 (65× magnification).

3.3. Surface texture
There were clear differences in the quality of the surface finishing of all three type of brackets. Fake brackets had an irregular and unpolished surface texture with visibly large alloy particles (Figure. 3). Crack lines and cavitation were evident on the bracket surfaces. The surface texture of real brackets was also irregular, with slightly large alloy particles. However, there were fewer cracks and no visible cavitation. In
contrast, the surface of the standard orthodontic brackets was smooth and polished. The particle size was small, with no visible cracks or cavitation. A detailed examination of the surface textures of fake and real brackets revealed irregularity and coarse alloy particles. Such a surface retains plaque and creates an environment favorable for bacterial colonization. Brusca et al. (2007) reported that microorganisms adhere best to brackets that are more porous and less smooth [16]. Several studies have investigated the influence of orthodontic therapy and appliances on the oral microbial flora, and the accumulation of microbial plaque on brackets is the main cause of demineralization and periodontal problems in orthodontic patients [17,18].

![Scanning electron microscopy of bracket surface texture for samples 1–9 (1000× magnification).](image)

**Figure 3.** Scanning electron microscopy of bracket surface texture for samples 1–9 (1000× magnification).

### 4. Conclusions

Our study can conclude that no toxic elements present in the fake or real braces samples. However, fake and real braces are flawed in two aspects: design and structure. There is a colossal difference in bracket design between fake, real and standard braces. The braces are not fabricated and designed for effective individual tooth movements. Furthermore, irregular and unpolished surface texture is prone to breakages, which would increase the potential of traumatic ulcers; swallowing and even aspiration of the fractured parts.

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