reveals, between casting and laser, there is a significant variation in transverse strength. Sig<0.05 suggests that there is a transverse strength difference between casting and laser. According to mean value laser has more transverse strength than casting.

Scanning electronic microscope: Figures 1 and 2 show SEM images of fragmented Co-Cr specimens, while Figure 3 displays the Co-Cr specimens' original intact smooth surfaces. The dendritic solidification microstructure in the casting group was in homogeneous, with dendritic zones and inters dendritic areas (Figure 2A). Casting specimens had a grain size of 20–100 μm. SLM groups with grain sizes of 2–20 μm showed a substantially finer and non-equilibrium structure.

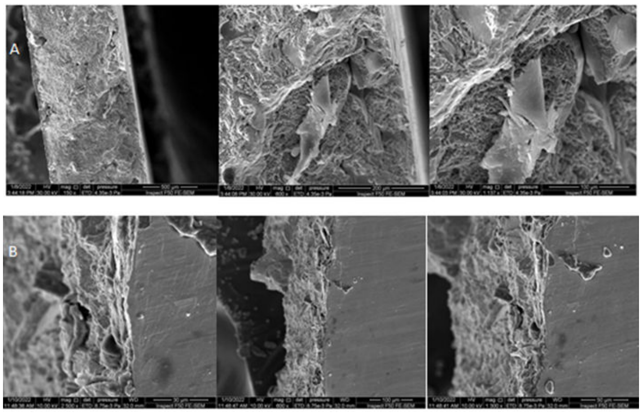

Figure 1: Scanning Electronic Microscope (SEM) pictures of broken surfaces created by; (A) Casting on Co-Cr alloy specimens (150-1100 mag); fracture area indicates irregular dendritic structure; (B) SLM, (600-2500 mag); fractured area indicate cleavage steps.

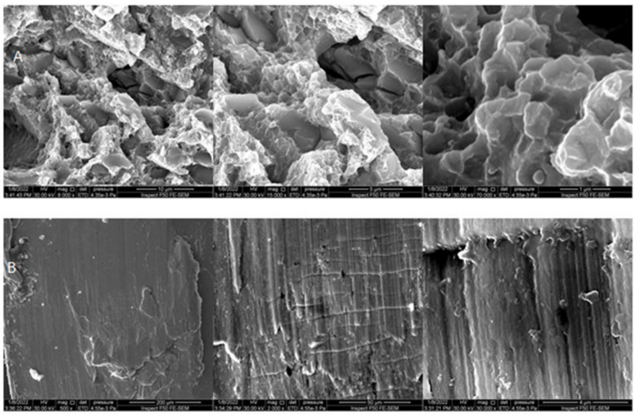

Figure 2: SEM pictures of Co-Cr alloy specimens with broken surfaces created by; (A) Casting (8000-70000); large crystalline structure indicate dendritic structures); (B) SLM (500-30000); area indicate cleavage steps.

Figure 3: SEM pictures of Co-Cr alloy specimens created by; (A) Casting with their original unbroken surfaces (70-500); the dark colored portions represent dendritic crystal formations that are irregular; (B) SLM (40-1000) there is microscopic crystalline formations that seem like white grains.

DISCUSSION

In the oral environment, the material is subjected to mechanical loading. When teeth or structures that replace teeth come into contact, such as during chewing, swallowing or bruxism, mechanical loading occurs, so it needs specific mechanical properties [27].

Depending on the primary purpose of the prosthesis, the choice of Co-Cr alloy is made by the dentist in collaboration with a dental technician. From this standpoint, several properties should be available in the alloy to be used. But most importantly, in this study, we focus on transverse strength and microstructure. Because they are most relevant to our demand in this study.

The mechanical characteristics of Co-Cr dental alloys were examined and compared using two different manufacturing methods (casting and selective laser melting techniques). The results of the study clearly demonstrated that the mechanical characteristics of alloys are highly dependent on production procedures as well as the chemical compositions of the alloys utilized. As a result, the null hypothesis that the groups made using different production procedures would have equal mechanical properties was rejected.

The specimens that will be used in transverse strength testing. The casting group had the largest elastic modulus, which means that a certain level of stress is necessary to distort a material. The laser group had a greater yield and flexural strength. Lower yield strength indicates lower levels of plastic deformation stress, while lower flexural strength indicates lower levels of flexion fracturing stress [28].

The mechanical characteristics of SLM and casting Co-Cr alloys were compared and casting group specimens were found to be inferior to SLM group specimens [29].

The casting group was tougher and absorbed more overall energy before breaking. The SLM group was the most vulnerable because it shattered at a low strain level [30].

SLM framework specimens were brittle and harder than castings, according to Co-Cr alloy bridges, but the SLM group was comparatively brittle due to breaking under less strain. The qualities of the final product can be affected by parameters such as, layer thickness, building direction and scan speed in the SLM manufacturing method [31].

SLM Co-Cr alloys benefit from post production heat treatment for releasing residual stress, resulting in a more homogeneous microstructure and improved mechanical properties [32]. The production process has an impact on the mechanical properties of the Co-Cr alloy.

The flexural strength and micro hardness of the Co–Cr alloy generated by AM were influenced by the build angle; however, it had no effect on surface free energy or surface roughness [33].

Metal framework mechanical properties, particularly flexural strength, are critical to metal ceramic restorations' long term clinical success.

The laser sintered metal frames had a flexural strength is higher than cast metal structures. The test group sintered with the shortest layer thickness had the highest flexural strength values, so the framework length increased, the flexural strength decreased [34]. Microstructure has a substantial impact on the mechanical performance of dental Co-Cr alloys. Cast specimens all exhibit a fibrous topography, which is caused by a higher plastic deformation till fracture. The size and location of segregations have a significant impact on the mechanical characteristics that affect fracture mechanisms [35].

The mechanical properties of the SLM alloy were improved. For metal ceramic restorations, Co-Cr dental alloy manufactured with SLM offers a viable alternative to conventional cast alloy [36]. SLM Co-Cr was less porous and had better mechanical properties than cast Co-Cr [37]. For constructing RPD frameworks, SLM followed by heat treatment is an effective method [38]. SLM technology can be used to make dental bridges and crowns, according to ISO 22674:2016 and ISO 9693-1:2012. For fixed dental restorations, SLM may be preferable to standard fabrication procedures [39].

Flexural strength of different settings additively manufactured commercial Co-Cr dental alloys shows different mean values. Sandblasting with Al_2O_3 and welding decrease flexural strength of Co-Cr alloy [40]. The flexural strength of casted samples is clinically acceptable [41]. Changing the interior architecture of metal frames reduces their weight but has no effect on their flexural strength or flexural modulus [42]. Porosity (inner and surface), residual stresses and chemical segregation were all found in the microstructures of casting and laser, all of which play a role in flexure load to fracture [43].

The results for flexural strength measurement in this research proved to be significantly superior in specimens produced by selective laser melting to those produced by casting techniques.

This is because flexural strength increases when the microstructure is uniform, fine grained and less porous. As a result, the SLM group's microstructure may justify its enhanced flexural strength. Microstructural heterogeneity and the existence of large holes in the cast group can operate as stress concentrators, causing failures; hence its reduced flexural strength may be justified [44].

The SEM study of the specimens reveals a generally evenly annealed microstructure with the typical shape of additive manufacturing technologies. Local porosity yellow circles have also been discovered in the specimens. There were no obvious variations in any of the selected locations. With grain sizes ranging from 50 to 100 µm and homogenous surfaces on the casting group nano scale crystalline forms on the SLM group's unbroken surface were discovered, whereas the fractured surface had a layered structure. It can be seen that the fracture of the casting group's broken surface happened simultaneously with the dendritic structure. The broken surface of the SLM group showed stair like cleavage steps, which are common in brittle materials.

After heat treatment, in the as built samples' x-y and x-z planes, many fine cellular and columnar dendritic features were less evident. In contrast, as cast samples had substantially bigger precipitates [45].

Due to dendritic segregation, the dendritic and inter dendritic zones have different solute distributions, which could affect mechanical properties.

The SLM groups, on the other hand, demonstrated a homogeneous and dense structure without pores, as well as complete local melting and quick solidification, defects and porosities are reduced. This could account for the SLM specimens' higher mechanical characteristics when compared to the casting group. Furthermore, the smallest grain size was found in the SLM samples, followed by the casting samples. When a fast cooling method like SLM is used instead of a long cooling process like casting, smaller grains are obtained [46].

Only the finest powder with an exceptionally narrow grain size distribution was chosen for the SLM powder [47]. When compared to the casting method, the Co-Cr alloy produced by SLM had significantly finer grains and better mechanical properties. Varied grain sizes can contribute to different mechanical characteristics in other alloys [48]. Grain refining can improve the alloy's strength, ductility and toughness, which could explain why SLM outperforms casting in terms of mechanical performance. Furthermore, rapid solidification of SLM specimens may improve mechanical performance by increasing the solute element solution limit and reducing dendritic segregation. Rapid solidification might strengthen the solution by preserving a high level of the supersaturated solid solution ingredient would precipitate later, enhancing the second phase strengthening effect.

Because of the entire local melting and rapid cooling of the SLM printing process, a dense structure with very homogenous grains and few porosities and defects may be produced, which explains the homogeneity.

The first microstructure of the selective laser melted Co-Cr alloy has a "fish scale" structure, which is a typical melt track created during the layer by layer laser melting process. SEM micrographs taken at low magnification show distinct melt track structures as well. The SLM Co-Cr alloy has a homogenous structure along the melt track, with elongated columnar grains and cellular like sub-grains [49].

The microstructure of the Co-Cr alloy is determined by the production process. In our research, SLM produces a more homogeneous surface with tiny grain size, whereas casting produces an irregular distribution of large scale size dendrites on unbroken surface while, in fractured surface in SLM stair like cleavage steps layer by layer, casting shows irregular dendritic structure.

Due of the quick cooling process based on laser melting, SLM has a homogeneous matrix. While, casting show presence of carbon and oxygen in carbides and oxides precipitates can affect their mechanical qualities. In the Co-Cr alloy microstructure, black patches represent oxides and dark white patches indicate carbides [50].

The solidification mechanism is determined by the cooling rate. While slow cooling during casting results in dendritic solidification, excessive cooling rates in SLM result in cellular solidification. Although some materials go through cellular eutectic solidification, the eutectics solidify as an intercellular network [51].

CONCLUSION

Within the limitation of this *in vitro* study, the following was concluded:

- Mechanical properties of SLM show a better result as compared to casting. SLM shows better transverse strength than casting.
- The microstructure of show homogenous surface with fine grain in SLM surface, while large irregular crystalline in casting.

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